AIR FORCE
STTR PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force STTR Program is with the Air Force Research Lab, Wright-Patterson Air Force Base, Ohio. The Air Force STTR Program Manager is Mr. Steve Guilfoos, (800) 222-0336. The Air Force Office of Scientific Research (AFOSR) is responsible for scientific oversight and program execution of Air Force STTRs.

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For general inquires or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (1 Feb through 13 Mar), contact the Topic Authors listed for each topic on the website. For obtaining answers to your technical questions during the formal solicitation go to (http://www.dodsbir.net/sitis).

The Air Force STTR Program is a mission-oriented program that integrates the needs and requirements of the Air Force through R&D topics that have military and commercial potential. Information can be found at the following website: http://www.afrl.af.mil/bc_sbir.asp

Unless otherwise stated in the topic, Phase I will show the concept feasibility and Phase II will produce a prototype or at least show a proof-of-principle.

Phase I period of performance is typically 9 months, not to exceed $100,000.

Phase II period of performance is typically 2 years, not to exceed $750,000.

The solicitation closing dates and times are firm.

FAST TRACK

Detailed instructions on the Air Force Phase II program and notification of the opportunity to submit a FAST TRACK application will be forwarded with all AF Phase I selection E-Mail notifications. The Air Force encourages businesses to consider a FAST TRACK application when they can attract outside funding and the technology is mature enough to be ready for application following successful completion of the Phase II contract.

NOTE:

1)Fast Track applications must be submitted not later Than 150 days after the start of the Phase I contract.
2) Fast Track phase II proposals must be submitted not later than 180 days after the start of the Phase I contract.
3) The Air Force does not provide interim funding for Fast Track applications.

For FAST TRACK applicants, should the outside funding not become available by the time designated by the awarding Air Force activity, the offeror will not be considered for any Phase II award. FAST TRACK applicants may submit a Phase II proposal prior to receiving a formal invitation letter. The Air Force will select Phase II winners based solely upon the merits of the proposal submitted, including FAST TRACK applicants.

PROPOSAL SUBMISSION INSTRUCTIONS

ALL PROPOSAL SUBMISSIONS TO THE AIR FORCE MUST BE SUBMITTED ELECTRONICALLY.

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD SBIR/STTR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **6:00am EST April 14, 2006** deadline. A hardcopy **will not** be accepted. Signatures are not required at proposal submission when submitting electronically. If you have any questions or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-866-724-7457 (8am to 5pm EST).

Acceptable Format for On-Line Submission: All technical proposal files must be in Portable Document Format (PDF) for evaluation purposes. The Technical Proposal should include all graphics and attachments but should not include the Cover Sheet or Company Commercialization Report (as these items are completed separately). Cost Proposal information should be provided by completing the on-line Cost Proposal form.

Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD solicitation. However, your cost proposal will only count as one page and your Cover Sheet will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in submitting your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your uploaded file will be virus checked and converted to PDF within the hour. However, if your proposal does not appear after an hour, please contact the DoD SBIR/STTR Help Desk.

The Air Force recommends that you complete your submission early, as computer traffic gets heavy near the solicitation closing and slows down the system. **Do not wait until the last minute.** The Air Force will not be responsible for proposals being denied due to servers being "down" or inaccessible. Please assure that your e-mail address listed in your proposal is current and accurate. By the end of April, you will receive an e-mail serving as our acknowledgement that we have received your proposal. The Air Force cannot be responsible for notifying companies that change their mailing address, their e-mail address, or company official after proposal submission.

COMMERCIAL POTENTIAL EVIDENCE

An offeror needs to document their Phase I or II proposal's commercial potential as follows: 1) the small business concern's record of commercializing STTR or other research, particularly as reflected in its Company Commercialization Report http://www.dodsbir.net/submission; 2) the existence of second phase funding commitments from private sector or non-SBIR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

ELECTRONIC SUBMISSION OF PROPOSAL

If you have never visited the site before, you must first register your firm and create a password for access (Have your Tax ID handy). Once registered, from the Main Menu:

Select "Prepare/Edit Phase I Cover Sheets" –

1. **Prepare a Cover Sheet.** Add a cover sheet for each proposal you plan to submit. Once you have entered all the necessary cover sheet data and clicked the Save button, the proposal grid will show the cover sheet you have just created. You may edit the cover sheet at any time prior to the close of the solicitation.
2. **Prepare a Cost Proposal.** Use the on-line proposal form by clicking on the dollar sign icon.
3. **Prepare and Upload a Technical Proposal.** Using a word processor, prepare a technical proposal following the instructions and requirements outlined in the solicitation. When you are ready to submit your proposal, click the on-line icon to begin the upload process. You are responsible for virus checking your technical proposal file prior to upload. Any files received with viruses will be deleted immediately.

Select "Prepare/Edit a Company Commercialization Report" –

4. **Prepare a Company Commercialization Report.** Add and/or update sales and investment information on all prior Phase II awards won by your firm.

NOTE: Even if your company has had no previous Phase I or II awards, you must submit a Company Commercialization Report. Your proposal will not be penalized in the evaluation process if your company has never had any STTR Phase Is or IIs in the past.

Once steps 1 through 4 are done, the electronic submission process is complete.

AIR FORCE PROPOSAL EVALUATIONS

Evaluation of the primary research effort and the proposal will be based on the scientific review criteria factors (i.e., technical merit, principal investigator (and team), and commercialization plan). Please note that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror. The Air Force anticipates that pricing will be based on adequate price competition. The next tie-breaker on essentially equal proposals will be the inclusion of manufacturing technology considerations.

The Air Force will utilize the Phase I evaluation criteria in section 4.2 of the DoD solicitation in descending order of importance with technical merit being most important, followed by the qualifications of the principal investigator (and team), and followed by commercialization plan. The Air Force will use the phase II evaluation criteria in section 4.3 of the DoD solicitation with technical merit being most important, followed by the commercialization plan, and then qualifications of the principal investigator (and team).

PROPOSAL/AWARD INQUIRIES

We anticipate having all the proposals evaluated and our Phase I contract decisions by mid-Aug. All questions concerning the evaluation and selection process should be directed to the Air Force Office of Scientific Research (AFOSR). The Air Force will send out selection and non-selection notification e-mails by mid-Aug.

ON-LINE PROPOSAL STATUS AND DEBRIEFINGS

The Air Force has implemented on-line proposal status updates and debriefings (for proposals not selected for an Air Force award) for small businesses submitting proposals against Air Force topics. At the close of the Phase I Solicitation – and following the submission of a Phase II via the DoD SBIR / STTR Submission Site (https://www.dodsbir.net/submission) - small business can track the progress of their proposal submission by logging into the Small Business Area of the Air Force SBIR / STTR Virtual Shopping Mall (http://www.sbirsttrmall.com). The Small Business Area (http://www.sbirsttrmall.com/Firm/login.aspx) is password protected and uses the same login information as the DoD SBIR / STTR Submission Site. Small Businesses can view information for their company only.

To receive a status update of a proposal submission, click the "Proposal Status / Debriefings" link at the top of the page in the Small Business Area (after logging in). A listing of proposal submissions to the Air Force within the last 12 months is displayed. Status update intervals are: Proposal Received, Evaluation Started, Evaluation Completed, Selection Started, and Selection Completed. A date will be displayed in the appropriate column indicating when this stage has been completed. If no date is present, the proposal submission has not completed this stage. Small businesses are encouraged to check this site often as it is updated in real - time and provide the most up - to- date information available for all proposal submissions**. Once the "Selection Completed" date is visible, it could still be a few weeks (or more) before you are contacted by the Air Force with a notification of selection or non – selection.** The Air Force receives thousands of proposals during each solicitation and the notification process requires specific steps to be completed prior to a Contracting Officer distributing this information to small business.

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Coversheet will be notified by Email regarding proposal selection or non-selection. The Email will include a link to a secure Internet page to be accessed which contains the appropriate information. If your proposal is tentatively selected to receive an Air Force award, the PI and CO will receive a single notification. If your proposal is not selected for an Air Force award, the PI and CO may receive up to two messages. The first message will notify the small business that the proposal has not been selected for an Air Force award and provide information regarding the availability of a proposal debriefing. The notification will either indicate that the debriefing is ready for review and include instructions to proceed to the " Proposal Status / Debriefings " area of the Air Force SBIR / STTR Virtual Shopping Mall or it may state that the debriefing is not currently available but will be within 90 days. If the initial notification indicates the debriefing will be available within 90 days, the PI and CO will receive a follow – up notification once the debriefing is available on - line. All proposals not selected for an Air Force award will have an on – line debriefing available for review. Available debriefings can be viewed by clicking on the " Debriefing " link, located on the right of the Proposal Title, in the " Proposal Status / Debriefings " section of the Small Business Area of the Air Force SBIR / STTR Virtual Shopping Mall**. Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced. Also observe the status of the debriefing as availability may differ between submissions (e.g., one may state the debriefing is currently available while another may indicate the debriefing will be available within 90 days).**

PHASE II PROPOSAL SUBMISSIONS

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees that are **invited** to submit a Phase II proposal and all FAST TRACK applicants will be eligible to submit a Phase II proposal. The Phase I award winners must accomplish the majority of their primary research during the first six months of the contract. Each Air Force organization may invite Phase II proposals prior to the completion of the first six months of the contract based upon an evaluation of the contractor's technical progress and reviewed by the Air Force Technical point of contact utilizing the criteria in section 4.3 of the DoD solicitation The awarding Air Force organization will send detailed Phase II proposal instructions to the appropriate small businesses. Phase II efforts are typically two (2) years in duration and do not exceed $750,000. (NOTE) All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system**. Get your DCAA accounting system in place prior to the AF Phase II award timeframe. If you do not have a DCAA approved accounting system this will delay / prevent Phase II contract award. If you have questions regarding this matter, please discuss with your Phase I contracting officer.**

All Phase II proposals must have a complete electronic submission. **COMPLETE** electronic submission includes the submission of the Cover Sheet, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal with any appendices via the DoD submission site. The DoD proposal submission site at http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Your proposal **must** be submitted via the submission site on or before the Air Force activity specified deadline. Phase II Technical proposal is limited to 75 pages. Phase II Cost Proposal information should be provided by completing the on-line Cost Proposal form. The commercialization report, any advocacy letters will not count against the 75 page limitation and should be placed as the last pages of the Technical Proposal file that is uploaded. (Note: Only one file can be uploaded to the DoD Submission Site. Ensure that this single file includes your complete Technical Proposal and the additional cost proposal information.)

PHASE I SUMMARY REPORTS

All Phase I award winners must submit a Phase I Final Summary Report at the end of their Phase I project. The Phase I summary report is an unclassified, non-sensitive, and non-proprietary summation of Phase I results that is intended for public viewing on the Air Force SBIR / STTR Virtual Shopping Mall. A summary report should not exceed 700 words, and should include the technology description and anticipated applications / benefits for government and / or private sector use. It should require minimal work from the contractor because most of this information is required in the final technical report. The Phase I summary report shall be submitted in accordance with the format and instructions posted on the Virtual Shopping Mall website at http://www.sbirsttrmall.com.

SUBMISSION OF FINAL REPORTS

All final reports will be submitted to the awarding Air Force organization in accordance with Contract Data Requirements List (CDRL). Companies **will not** submit final reports directly to the Defense Technical Information Center (DTIC).

AIR FORCE STTR PROGRAM MANAGEMENT IMPROVEMENTS

The Air Force reserves the right to modify the Phase II submission requirements. Should the requirements change, all Phase I awardees that are invited to submit Phase II proposals will be notified. The Air Force also reserves the right to change any administrative procedures at any time that will improve management of the Air Force STTR Program.

Air Force STTR 06 Topic Index

Air Force STTR 06 Topic Descriptions

AF06-T001 TITLE: Innovative High-Power Propulsion Technologies for Orbital Transfer Vehicles

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop new concepts of high-power electric propulsion with simultaneous high thrust and high specific impulse, for rapid maneuvering of large space assets.

DESCRIPTION: US space assets need to be protected and maintained in times of crisis. The ability to rapidly perform space maneuvers, between various orbital inclinations, or between geostationary and low earth orbits, is a very desirable capability. For large satellites, this requires large peak power and high thrust levels. It is also potentially advantageous that these maneuvers be performed by the propulsion system of a separate, Orbital Transfer Vehicle (OTV), thus enabling the satellite to use its own propulsion system for station-keeping if necessary, or other minor space maneuvers. Chemical propulsion becomes prohibitive for these types of missions, due to the high propellant mass requirements; it is therefore imperative that the OTV propulsion concept has a high specific impulse (Isp) to allow several missions without refueling. Electric propulsion concepts are able to provide such high Isp, but usually at the expense of thrust or efficiency. For example, ion thrusters and Hall thrusters can have high Isp (1500 - 5000 sec), but the low plasma density greatly limits the thrust level. Higher thrust concepts, such as arc-jets, can provide higher thrust, but the Isp is only of the same order (x2) as chemical propulsion concepts. What is desired instead, is a high efficiency (> 70%) propulsion system capable of thrust levels commensurate to chemical propulsion (1N – 1kN), but with an Isp that is an order of magnitude better (at least > 3000 sec, preferably > 5000 sec). The proposed concept can be designed in isolation from the power source, or as a propulsion system integrated with a power source. Dual-use concepts, for other applications such as power generation, remote diagnostics or defensive operations, are of special interest.

PHASE I: Provide engineering analysis or small-scale experimental demonstration of the proposed device or validity of the proposed approach; identify key requirements for validating the technology; propose approach for Phase II demonstration; identify dual-use and commercialization potential.

PHASE II: Demonstrate the technology with small-scale experiments, or experiments aimed at verifying key aspects of the concept for overall concept validation; provide detailed plan for scaling-up and additional testing; construct and implement commercialization plan.

DUAL USE COMMERCIALIZATION: Military application: An OTV itself would have commercial applications for servicing commercial satellites, extending their useful life-times by boosting their orbits and providing insurance against misplaced satellites.

REFERENCES: 1. R. Frisbee, J. Prop. & Power, vol. 19 (6), 1129 (2003).

2. D.-Y. Chang and C. N. Chang, “Deflagration Plasma Thruster”, in AIAA Progress in Aeronautics and Astronautics, vol. 89, (1984), L.H. Caveny ed.

3. J. Slough, “Rapid Manned Mars Mission with a Propagating Magnetic Wave Plasma Accelerator”, NASA Institute for Advanced Concepts, Phase I Final report, 1998.

4. B. Smith, S. Anghaie, Nuclear Techn., vol. 145 (3), 311 (2004)

KEYWORDS: propulsion, orbital transfer vehicle, plasma, MHD, FRC, MPD, nuclear, beam

AF06-T002 TITLE: Nanodielectrics for High Power Capacitors and Passive Applications

TECHNOLOGY AREAS: Air Platform, Electronics

OBJECTIVE: To develop new dielectrics with nanoscale control of electronic properties demonstrating dramatic enhancements in dielectric constant (orders of magnitude), voltage breakdown strength (> 5X), insulation resistance and low losses (< 0.01) for applications in pulsed power and aerospace power conditioning and control.

DESCRIPTION: High density, high performance power conditioning and control electronics are needed to place compact, reliable electrical power on air and space platforms to support more electric aircraft as well as high voltage loads for directed energy weapons. Lightweight, compact, high energy density capacitors capable of operation at several mega joules per pulse and repetition rates on the order of 100 pps bursts are needed for directed energy weapons. High altitude operation places extra physical and structural demands on power components. Nanomaterials with unique chemical and physical properties have potential to make revolutionary advances in the area of advanced dielectrics for these applications. Nanostructured dielectrics offer the opportunity to tailor the dielectric material on the nanometer scale to provide tremendous improvements in electrical, mechanical and thermal properties for specific applications of particular interest to the Air Force such as high energy density capacitors, passivation, and insulation for compact, high power and high voltage power conditioning and pulsed forming networks for directed energy applications. Innovative approaches utilizing unique capabilities enabled by nanostructured dielectrics are needed to provide increased energy densities by enhancement in the dielectric constant (theoretically range from 2-15 to as high as tens of thousands) and improved breakdown strength (by over 2X for polymers composites to orders of magnitudes for nanocomposite ceramics) over conventional dielectrics. Developing a fundamental understanding of the interactions and physical processes that may develop between molecules, atoms and small clusters of atom (10^3 to 10^6 atoms) in nanometric scale regimes such as quantum confinement effects and space charge polarization from nanoparticles or nanowires at low percolation densities will be critical to the optimization and reproducibility of new nanodielectric materials. Thus, the development and/or utilization of models and simulations that enable an understanding of how the enhancement of the macroscopic properties such as dielectric constant, losses, breakdown strength and mechanical stability arise from engineering the material on the nanometric scale, and validating them with experimentation will be essential to a successful program. Voltage reversal, corona resistance, graceful failure, self-healing capability, mechanical properties, thermal stability, compatibility with materials used for device fabrication, lifetime and packaging issues also need to be considered. Potentially useful approaches may explore theoretical and experimental aspects of developing nanodielectrices utilizing techniques such as electronic or ionic self-assembled monolayer deposition, atomic layer deposition (ALD), or sol-gel deposition, nanoparticle dispersion processes. Some examples of nanomaterial technologies that may be of interest include, but are not limited to; hybrid nanocomposite materials consisting of polymers including epoxies with polyhedral oligomeric silsesquioxanes (POSS) or nanoengineered films using poly(amidoamine-organosilicon) PAMAMOS dendrimers for ceramic nanocomposites, two-phase composites of either ceramic nanoparticles in polymer matrices, nanoscale conducting materials such as carbon nanotubes in an insulating media, or multi-phase composites nanometric layered structures with dielectric gradients.

PHASE I: Demonstrate nanoscale manipulation of electrical properties through both testing & simulation, study & understand nanoscale dielectric behavior & show feasibility of forming high energy density capacitor devices with low losses, high breakdown strength & suitable mechanical & thermal properties.

PHASE II: Demonstrate packaged, prototype high energy density, high performance capacitors fabricated from optimized nanodielectric materials operating in a bread board level pulsed forming network and/or in power converter circuit.

DUAL USE COMMERCIALIZATION: Military application: High energy density capacitors for power conditioning in compact, high power electrical systems for manned & unmanned air vehicles, pulsed power capacitors for directed energy weapons & insulation Commercial application: Capacitors for uninterrupted power supplies, utility distribution substations, medical defibrillators, aircraft ignition systems & insulation for compact & highly efficient electric machines.

REFERENCES: 1. M.L. Fre'chette, M.L. Trudeau, H.D. Alamdari & S.Boily, "Introductory Remarks on Nanodielectrics", IEEE Trans.on Diel.& Elect.Insul. 11 (5), (2004) 808-818.

2. J.K. Nelson & J.C. Fothergill, "Internal Charge Behavior of Nanocomposites", Nanotechnology 15, (2004) 586-595.

3. Y.Cao, P.C. Irwin & K.Younsi, "The Future of Nanodielectrics in the Electrical Power Industry", IEEE Trans.on Diel.& Elect.Insul. 11 (5), 797-807 (2004).

4. T.J. Lewis, "Nanometric Dielectrics", IEEE Trans.on Diel.& Elect.Insul. 1(5), (1994) 812-825.

KEYWORDS: nanodielectrics, dielectrics, nanotechnology, nanocomposites, nanostructured dielectrics, high energy density capacitors, passivation, power conditioning, pulsed forming networks

AF06-T003 TITLE: Quantitative Model of Human Dynamic Attention Allocation

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop quantitative model(s) of attention allocation in dynamically complex multi-modal task environments.

DESCRIPTION: It is well known that the simplicity of regularly timed event sequences afford behavioral synchronization and anticipation for upcoming events in the sequence. This is because such event sequences are essentially predictable over a certain time scale. Recent findings demonstrate the importance of timing for the perceptual processing of complex event sequences as well. These results suggest that attention exploits temporal predictability by coordinating perception, cognition, and action in a way that is optimally efficient for a given task environment. However, in rapidly changing, dynamically complex work environments effective task management can quickly deteriorate when information arriving from multiple sources begins to arrive at unexpected and/or inconvenient times and thus, may function to interrupt a procedure, or chain of thought. Failures to update, pickup critical information, or take appropriate action in a timely manner can quickly accumulate in a ripple effect until the operator becomes cognitively overloaded. The implication here is that appropriate attentional allocation among tasks becomes impossible and a breakdown in coordination among attention, perception and action occurs. Thus, it is imperative that display designers have tools to create adaptive interfaces for portraying dynamic information in such a way to guide operator perception and attention to appropriate incoming data "when and where" it is needed. For example, in our C2 environments where analysis of time sensitive information is critical, rapid analysis of multisource data is required to support Netcentric Intelligence operations in a timely manner. Therefore, this Small Business Technology Transfer (STTR) call is for development of an innovative quantitative model(s). Key model requirements are: (1) the model must capture the timing and spatial parameters of dynamic information structures produced by multiple information sources in complex task environments, and (2) the model must characterize attentional expenditure patterns related to the spatio-temporal characteristics of dynamic information flow. Thus, the model must be able to incorporate both the dynamic structural characteristics of visual and auditory task information, as well as the operator's behavioral responses to this information over time.

PHASE I: Develop an innovative approach to the problem, describing how the approach differs from current ones and solves the problem posed. Provide a prototype(s) based on this approach; demonstrate that prototype meets the key model requirements using multi-modal stimuli in a dynamic task environment.

PHASE II: Expand PHASE I prototype software to include complex task environments and operator input measures. Test model's reliability and efficacy using multi-modal dynamic information within different task paradigms. Demonstrate real-time model performance. Integrate the software into reconfigurable Simulated Task Environment (STE) for development of adaptive interface designs.

DUAL USE COMMERCIALIZATION: Military application: Real-time models are important for adaptive interfaces to support portrayal of dynamic information in Time Sensitive Target (TST) and Intelligence Analysis operational environments. Expected usage of model(s) commercialization is to advance and accelerate real-time embedded training for military and civilian defense disaster preparedness; air traffic control; and classroom education.

REFERENCES: 1. Jones, M.R., & Skelly, J.J.: "The Role of Event Time in Attending" Time and Society, Vol.2 (1), pp 107-128, 1993.

2. Kelso, S.J.: “Dynamic Patterns: The Self-Organization of Brain and Behavior, “ MIT Press, Cambridge, MA, 1995.

3. Large, E.W. & Jones, M.R.: “The Dynamics of Attending: How We Track Time Varying Events” Psychological Review, 106, pp 119-159, 1999.

4. Skelly, J.J.: “Time: Our Lost Dimension of Interface Design” Proceedings of BRIMS 2003 Conference, May 11-15, 2003, Scottsdale, AZ.

KEYWORDS: dynamic information, information portrayal, attention allocation, dynamical systems, real-time

AF06-T004 TITLE: Exploiting Raster Maps for Imagery Analysis

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop methods to find online raster maps, determine the geocoordinates of the maps, and exploit the maps for imagery analysis.

DESCRIPTION: Given the vast quantities of imagery available to the analyst, a critical problem is how to support an intelligence analyst in rapidly interpreting the imagery. An important part of this problem is analyzing the context of the imagery (i.e., what is in the area of interest, what are the streets and buildings in the image, etc.). Maps provide a wealth of information that can help in the interpretation of imagery. There are several problems that must be addressed in order to fully exploit the available maps. First, a system must search for the relevant maps. There are numerous map collections distributed on the Internet and few of them provide the metadata to indicate the coordinates of the maps. Second, given a possibly relevant map, in order to exploit the maps requires registering the map with the imagery. Third, in order to fully exploit a map for image analysis requires extracting both the textures (such as roads, open spaces, etc.) and the text (such as street names, building names, etc.) from the map. Extracting the textures is difficult because the text often obscures the textures and extracting the text is challenging because the text can be oriented in any direction and often follows the curves of the roads (commercial OCR systems do not work on the text often found on maps). Once this information is extracted, it can be used to both label and support additional processing on the imagery.

PHASE I: Develop an approach to finding, registering, and extracting both textures and text from online raster maps to support imagery analysis. Build a limited proof-of-concept to demonstrate the feasibility of the approach.

PHASE II: Build a complete end-to-end system that takes an image for a given area, finds a set of relevant maps, registers the maps to the imagery, and extracts the textures and the text labels from the maps to support imagery analysis. The system should provide a web-based user interface for use by an analyst.

DUAL USE COMMERCIALIZATION: The resulting technology will be useful for a variety of military applications that involve imagery analysis and targeting. Commercial application: The technology will also be useful for a various commercial applications including urban planning, emergency response, real estate, and related GIS applications.

REFERENCES:
1. Reference 1 Cao, R. and Tan, C. L., “Text/graphics separation in maps.” In the Fourth International Workshop on Graphics Recognition Algorithms and Applications (GREC 2001), Kingston, Ontario, Canada, September, 2001.

2. Reference 2 Chen, C., Knoblock, C.A., Shahabi, C., Chiang, Y., Thakkar, S., Automatically and Accurately Conflating Orthoimagery and Street Maps , The 12th ACM International Symposium on Advances in Geographic Information Systems (ACM-GIS'04), Washington, D.C., USA, November 2004

3. Reference 3 Saalfeld, A., “Conflation: Automated Map Compilation,” Technical Report CS-TR-3066, Center for Automation Research, University of Maryland, May 1993.

KEYWORDS: imagery analysis, raster maps, map registration, conflation, text/graphics separation, map search

AF06-T005 TITLE: Combustion Stability Innovations for Liquid Rocket

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop innovative methods for mitigating against the risk of developing combustion instabilities in liquid rocket engines.

DESCRIPTION: The consequences of developing combustion instabilities in liquid rocket engines are perhaps more catastrophic than in other applications due to the higher temperatures and higher pressures involved – both of which exacerbate high heat transfer rates to the wall as the primary destruction mechanism. Engines can be destroyed in a fraction of a second, and this exceedingly short time scale presents severe challenges to conventional active control approaches. As a result, other innovative approaches to mitigating against the risk of developing combustion instabilities in liquid rocket engines also need to be sought. This does not preclude active control approaches; examples include slow control approaches [1] and approaches based on monitoring random combustion noise. [2] However, methods beyond active control also need to be sought. Innovations in advanced predictive capability are envisioned to play an important role, for instance. For example, innovative acoustic drivers capable of producing steep-fronted, non-linear waves at high pressure and high temperature conditions are needed to produce the required validation data for more accurate predictions. Some advancements in this area have previously been made,[3] but those drivers in question do not withstand high temperatures well, and it could be desired that they drive a higher percentage of chamber pressure in magnitude. Innovative advances in predictive methodologies themselves could also be important, whether they be algorithmic, numerical, or some fundamentally different approach. Other possibilities may exist which have not been envisioned here.

PHASE I: Identify and demonstrate the feasibility of innovative methods for mitigating against the risk of developing combustion instabilities in liquid rocket engines, including active and passive techniques, engineering tools, and research tools.

PHASE II: Develop the concept(s) identified in Phase I either into a workable prototype, or demonstrate operation in a suitably realistic system.

DUAL USE COMMERCIALIZATION: Military application: Combustion stability is a broad national problem spanning air breathing gas turbines, ram/scram jets, and liquid rocket propulsion, as well as land-based power.

REFERENCES: 1. Lubarsky, et. al., IGTI 2005.

2. Lieuwen, T., “Online Combustor Stability Margin Assessment Using Dynamic Pressure Data,” Proceedings of the ASME/IGTI Turbo Expo, paper GT 2004-53149, Vienna, Austria, June 14-17, 2004.

3. Davis, D., and Chehroudi, B., “The Effects of Pressure and Acoustic Field on a Cryogenic Coaxial Jet,” 42st AIAA Aerospace Sciences Meeting and Exhibit,” paper AIAA 2004-1330, Reno, NV, 5-8 January 2004.

KEYWORDS: combustion instabilities, liquid rockets, active control, passive control, acoustic drivers, predictive methodologies

AF06-T006 TITLE: Nano-scale Optical Components

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Fabricate optical components employing subwavelength structures exhibiting particular polarizing, reflecting, and transmitting properties in the ultra-violet to terahertz spectral regions.

DESCRIPTION: In recent years, an exciting new class of nano-structured materials has emerged paralleled by novel nano-patterning tools to create these structures. The nano-scale optical properties of these materials can be engineered such that surface effects can produce a number of novel and useful phenomena. Examples include but certainly are not limited to surface gratings, two dimensional photonic crystals used in atypical oblique incidence angles, effective medium optical composites, and motheye coatings. The theoretical descriptions of these materials must include detailed solutions of Maxwell's equations in order to cover the range of possible responses and applications. Typical bulk optical components do not necessarily require the same level of modeling sophistication for their description. The structures may be constructed with innovative nano-patterning techniques out of functional component materials to achieve the desired response and manipulation of polarization, phase, wavelength, and other optical properties.

Future battlefield systems will exploit highly sophisticated optical detection systems and communications networks connecting command and control with dense arrays of intelligent sensors, compact reconnaissance platforms, and manned and unmanned military assets. These environments will need ultracompact, lightweight, low-power, low-cost optical sources; antenna transmitters; and detectors. In turn, these technologies will require advances in the design of ultracompact microphotonic structures: the design and engineering of the electromagnetic properties of the materials will be on a sub-wavelength scale. Successful completion of this program will aid the development of scaled optical imaging systems and high quality, robust, photonic circuits that will serve as an integrating medium for optical components and networks and that will perform basic, on-chip functions (such as signal conditioning and signal processing).

PHASE I: Demonstrate feasibility of optical devices with nano-scale structures for the manipulation of light in UV to THz spectral regions that exhibit particular optical properties such as polarization, reflection, and transmission. Identify application, integration and performance parameters.

PHASE II: Build upon Phase I work and demonstrate a system of one or more variations of the components and implementation of a working prototype. Perform appropriate analysis and modeling, design the materials and other elements, fabricate the device and test its performance. Address the issues of integration into an optical system requiring the functionality provided by the prototype.

DUAL USE COMMERCIALIZATION: Military application: Applications of the nano-optical elements include remote smart sensors, spectrum analysis, signal processing and communications. Commercial application: Enable the fabrication and design of optical components employing nano-scale surface structures, which lead to highly functional OE circuits in the ultraviolet to infrared to terahertz range.

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KEYWORDS: optical components, optical subcomponents, nanotechnology, optical properties, nano-structured materials, nano-patterning, plasmonics, sub-wavelength components, integrated devices, integrated components, optical networks, light waves, nano-fabrication, detectors, sensors, near-field optics, optical interactions at the nanometer scale, near-field optical memory, nano-scaled optical imaging, infrared, terahertz, photonic crystal and subwavelength optical elements

AF06-T007 TITLE: Environmentally-Benign Oxidizers for Propulsion

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop new oxidizers which can serve as halogen-free, greener replacement for ammonium perchlorate (AP) in solid-propellant formulations.

DESCRIPTION: Ammonium perchlorate (AP) is the most commonly used oxidizing ingredient in solid propellant formulations. It carries a sufficient excess of oxygen to allow for the combustion of the required binder and added metal, such as aluminum. One major drawback of AP is its chlorine content which results in the formation of hydrochloric acid (HCl) as a combustion product and can cause environmental problems. This drawback can be overcome by the use of halogen-free oxidizers, such as ammonium nitrate (AN) or ammonium dinitramide (ADN). However, AN and ADN both provide less available oxygen, 20.0 and 25.8 weight %, respectively, than AP (34.1 weight %) and, therefore, result in significantly reduced performance of their formulations. A second major drawback to AP is its high solubility in water (20g/100g water at 0°C) and subsequent contamination of ground and drinking water. Further, it is highly mobile and persistent in ground-water systems and the Environmental Protection Agency currently lists over one hundred known release sites in the U.S.

The goal of this solicitation is the identification and characterization of novel replacements for AP which provide comparable or more oxygen relative to AP, while at the same time being more benign in the environment. These replacements should also have a low health hazard and low water solubility or low ground water mobility and persistence. Finally, these replacements should exhibit similar or better shock insensitivity than AP.

PHASE I: Identify potential AP replacement candidates and predict their combustion products and performance in solid propellant formulations. Design strategies and experimental approaches for environmentally benign syntheses and demonstrate proof of concept of synthetic approach. Predict toxicity.

PHASE II: Synthesize and characterize the most promising candidates identified during Phase I. Develop synthetic methods for their low-cost, large-scale production.

DUAL USE COMMERCIALIZATION: Military application: High performance propellants for missiles and launch vehicles that satisfy environmental regulations. Commercial application: Environmentally benign and sustainable propellants for commercial space launch vehicles.

REFERENCES:
1. A. Dadieu, R. Damm, E. W. Schmidt, “Raketentreibstoffe,’’ Springer Verlag, Wien, New York, 1968.

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KEYWORDS: halogen-free, high-oxygen carriers, ammonium perchlorate replacement, solid propellant ingredients

AF06-T008 TITLE: Scalable Mobile Wireless Mesh Networks

TECHNOLOGY AREAS: Information Systems, Electronics

OBJECTIVE: The objective of this effort is to improve the effectiveness of scalable wireless mesh networks in bulk data transfer and multimedia streamlining.

DESCRIPTION: Several studies have independently shown the performance of 802.11-based mesh networks degrades rapidly as the number of hops increases. This degradation is due to a variety of reasons including inefficient medium access control, radio interference, and wireless link errors because of changing channel conditions, frequent route changes, and improper TCP interaction with lower-layer protocols. Meshes based on newer technologies such as WiMAX could alleviate these problems by using innovative protocols.

In addition, wireless mesh networks are vulnerable to security attacks. Current security approaches may be effective to a particular threat in a specific protocol layer but lack a comprehensive mechanism needed to prevent counter attacks in a different protocol layer.

PHASE I: The proposer should develop innovative 802.11-based (WiFi) and 802.16-based (WiMAX) mesh protocols that can effectively perform the bulk data transfer, multimedia streamlining, and multilayer security required in reach-back networking operations in a battlefield.

PHASE II: Given the baseline protocols developed in Phase I, the proposer will modify, where appropriate, protocols based on experimental data collected to illustrate the performance of the secure wireless mesh networks as a function of number of hops, traffic load, and node density and mobility.

Finally, the proposer will demonstrate a secure wireless mesh network that is scalable in both the number of nodes and the number of hops in the network. This will be done without having to increase the complexity of the network nodes as is commonly done today, but rather through the design of the MAC, routing, and transport protocols.

DUAL USE COMMERCIALIZATION: Military application: Scalable wireless mesh networks provide a rapidly deployable means to communicate high data rate information to the battlefield. Commercial application: Scalable wireless mesh networks show promise as an inexpensive replacement for T1/T3 lines.

REFERENCES:
1. I. Akyildiz, X. Wang, and W. Wang, "Wireless mesh networks: a survey," Computer Networks, to appear.
2. J. Bicket, D. Aguayo, S, Biswas and R. Morris, "Architecture and Evaluation of an Unplanned 802.11b Mesh Network," MobiCom '05.

KEYWORDS: Wireless mesh networks, ad-hoc networks, sensor networks.

AF06-T009 TITLE: Innovative Measurement Approaches for Harsh, Chemically Reacting Environments

TECHNOLOGY AREAS: Air Platform, Chemical/Bio Defense, Space Platforms

OBJECTIVE: Develop new classes of techniques to perform required measurements in harsh, chemically reacting environments with application to liquid rocket engine combustion chambers.

DESCRIPTION: In many applications, measurement approaches are dictated more by what it is possible to measure rather than by what is required to be measured. For example, in a liquid rocket engine, inlet propellant temperatures are measured somewhere in the manifold where it is possible and convenient to measure them, whereas accurate temperature measurements precisely at the exit plane where the propellants are injected into the combustion chamber may be what is really required if propellant properties depend sensitively on the temperature there.1 The inability to perform the measurements that are really required forces compromises that can impact various applications in large ways. For example, it can force large compromises in the way a process is controlled during operation, even to the extent that certain processes may become uncontrollable. In addition to controllability, the inability to measure a required quantity can force compromises which make it difficult or impossible to reveal important physical processes that drive other key requirements an application might have, such as performance, lifetime, cost, and reliability. Such compromises can and do impact the fundamental design of a device, such as building in design margin that would not otherwise be required, which in turn can have a large impact on cost and even feasibility. Here, innovative new techniques are sought for harsh, chemically reacting environments with application to liquid rocket engine combustion chambers. Harsh, chemically reacting environments can restrict the application of measurement techniques in many ways. Physical probes may not survive, while the media may at the same time be optically dense enough due to soot or dense sprays to frustrate the use of optical approaches. Even when optical approaches at least seem possible, many factors can still render them difficult at best to use, such as high pressures, index of refraction variations, blooming near walls, window contamination, dirt, vibration, and others. Innovative new approaches may be possible in several respects: the development of completely new classes of techniques, more clever application of existing techniques to existing applications, or the use of an existing technique in applications where it has never been used before. Examples of the latter which have so far seen little or no application in liquid rocket engines include laser induced breakdown spectroscopy 2 and ballistic imaging.3 An example of a way to more cleverly use existing techniques in existing applications might be more clever ways to implement and thermally protect windows in combustion chambers. The propellants of most interest to which the measurement approaches should be directed include liquid and/or gaseous oxygen, combined with hydrogen and/or various liquid hydrocarbons including but not limited to methane and kerosenes such as RP-1 and jet fuels. Appropriate of these propellants may also be considered if it facilitates development of the approach.

PHASE I: Identify and demonstrate the feasibility of an innovative technique for performing measurements in harsh, chemically reacting flow. The technique must be applicable to liquid rocket engine combustion chambers, as either an engineering or research tool.

PHASE II: Develop the concept(s) identified in Phase I into a workable prototype instrument.

DUAL USE COMMERCIALIZATION: Military application: The topic described here has significant applications in the areas of spacelift, space platform, and missiles. Commercial application: This topic is purposefully defined such that any technique which successfully passes phase II should have over reaching broad application with significant commercial potential.

REFERENCES: 1. Davis, D., and Chehroudi, B., “The Effects of Pressure and Acoustic Field on a Cryogenic Coaxial Jet,” 42st AIAA Aerospace Sciences Meeting and Exhibit,” paper AIAA 2004-1330, Reno, NV, 5-8 January 2004.

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KEYWORDS: space control and support, spacelift, space power, space propulsion

AF06-T010 TITLE: <u>Periodically Oriented Nonlinear Optical Materials</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: A commercial source of periodically oriented nonlinear materials and devices based on them.

DESCRIPTION: Recently there have been extremely promising accomplishments in the fabrication of periodically oriented III-V semiconductor materials, especially gallium arsenide, and their use in efficient quasi-phase-matched nonlinear devices. Using periodically oriented gallium arsenide, efficient second harmonic generation of CO2 laser radiation as well as broadly tunable optical parametric oscillation have been demonstrated.

Lithographically defined periodically oriented gallium arsenide thin films were first developed at Stanford University using a processing technique based on molecular beam epitaxy. The resulting thin films have been used as templates to overgrow periodic bulk structures, using vapor phase epitaxy.

It is the purpose of this STTR to further develop equipment and processes for producing periodically oriented gallium arsenide or other suitable III-V materials, to make them more reliable and efficient, suitable for creating a commercial market for the materials, fabrication equipment, and/or devices and systems based on the quasi-phase-matched materials.

PHASE I: Perform analysis and preliminary experiments to define equipment and processes necessary to become a commercial periodically oriented III-V semiconductor material and device supplier.

PHASE II: Develop capabilities, relationships, and prototype equipment sufficient to supply at least modest quantities of standard and custom III-V periodically oriented materials for commercial markets for nonlinear optical devices.

DUAL USE COMMERCIALIZATION: Military application: There are broad military needs for nonlinear frequency converted optical devices in the infrared (IR), including especially countering IR heat seeking missiles and gas sensing applications. Commercial application: Civilian needs also include infrared countermeasures and gas sensing for, e.g. leak detection, pollution monitoring, and process control, and medicine.

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KEYWORDS: periodically oriented, nonlinear optics, quasi-phase matching

AF06-T011 TITLE: Developing High Fidelity Synthetic Task Research Environments Using Gaming Technology

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Demonstrate the modification and use of gaming technology to create an exemplar high fidelity synthetic task environment for training and skills assessment research.

DESCRIPTION: Over the past ten years a number of agencies have attempted to develop high fidelity synthetic task environments (STEs) that faithfully present key military activities and constructs in an engaging and research-oriented computer-based environment. STEs have typically been very expensive to develop and even more costly to maintain and extend. While opinions and actual evidence on the true cost of developing a single STE vary, it is unquestionable that STEs require substantial upfront investment and continued support throughout their life span. STEs possess a number of unique qualities that make them ideal vehicles for research. First, they are designed around one or more critical functional areas such as air battle management or unmanned aerial vehicle operations. Second, they are designed so that key aspects of the environment can be modified and controlled for specific experimental studies in individual and team performance, task awareness, collaboration, and coordination, can be performed. Third, they are designed from a research perspective. That is, they have features and capabilities that permit very specific data to be gathered and packaged for subsequent analysis. Fourth, they faithfully represent many aspects of military environments and operations such that results from studies accomplished using STEs can be generalized to military contexts quite readily. Recently there has been a growing recognition of the potential role that interactive games may have as environments for training and rehearsal for military personnel. Games, however, are not typically designed with either a research or training focus. A typical gaming company will spend as much as $10 million to bring a high fidelity game to market. The growth of the military's interest in gaming is exemplified by the Defense Advanced Research Project Administration (DARPA) DARWARS initiative and the US Army's collaboration with the University of California Institute for Creative Technology. The present effort proposed here will examine the research potential associated with the modification of a commercial gaming environment for use as a research and assessment environment for individual and team tasks. This effort will conduct a series of controlled studies within the academic research laboratories developed as part of the Mesa Research Site University Consortium. The studies will accomplish the following activities. First, develop specifications for modifications to the candidate gaming environment as a synthetic task environment for training and assessment. Second, develop specifications for performance measures and protocols for assessing proficiency and decay for the gaming environment as an STE. Third, identify and validate training strategies and scenarios that support the development and refresher of skills associated with complex performance within the STE. Specifically, what are characteristics of strategies and scenarios that support development and refresh of critical knowledge and skills. Also what are some preliminary guidelines for refresher training intervals for different "classes" of skill. Fourth, develop team-level assessments of skill retention and decay applicable within the STE and across other gaming environments (as STEs). This will also include examining a range of training strategies and network characteristics needed to promote skill development and retention at the team level of analysis and measurement. Fifth, demonstrate real-time scenario authoring and skills warehousing and tracking capability that can be integrated into other gaming/training environments.

PHASE I: Identify candidate gaming environment and develop specifications for gaming/training and assessment refinements. Demonstrate preliminary modifications to gaming environment for use as an STE. Identify candidate metrics and skills sets for Phase II development.

PHASE II: Build a functional exemplar of the gaming environment as a training and research STE. Demonstrate one-time and routine assessment and performance tracking of individual and team performance in a distributed training context. Demonstrate skills assessment warehousing and scenario authoring capabilities of the STE.

DUAL USE COMMERCIALIZATION: Gaming environments are becoming ubiquitous within the entertainment industry. The development of business applications that are game-based has not been a motivation for gamers in the past, but these applications open up profit centers and commercialization opportunities for commercial exploitation and leverage. This effort will be a driver for the development of a next generation and flexile gaming capability that has the interfaces and tools built in to permit organizations to leverage gaming as training and readiness capabilities for their workforces. Additionally, the private and public sectors can leverage the substantial investment gaming companies are making to improve the quality of their workforce using technology and tools that are motivational, engaging, have high cognitive fidelity with respect to workplace activities, and where documented assessments of performance gains can be obtained.

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KEYWORDS: assessment, distributed training, gaming environments, online games, individual assessment, team assessment, synthetic task environment, human systems integration

AF06-T012 TITLE: Modeling/Simulation of Solid Rocket Propellant

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Provide a code to accurately predict the entire flight of aluminum particles from propellant surface through the nozzle exit plane (for nozzle impact studies and plume signature studies) together with a prediction of the effective properties (thermal conductivity and measures of mechanical strength such as Young’s modulus, Poisson’s ratio) of the binder, ammonium perchlorate, and aluminum spheroids which together constitute a solid propellant.

DESCRIPTION: A code is sought that will accurately model/simulate the effective properties and burning of composite solid rocket propellants. Composite propellants are composed of energetic particulates, typically of ammonium perchlorate (oxidizer) and aluminum (fuel) bound together with a polymeric binder constituting ~10-12% of the propellant volume. Particulate packing is critical to both the combustion and mechanical properties, so the code must contain a robust spheroid packing capability. Once the packs have been created numerically, they must be burned numerically. The code should predict the statistics of the aluminum agglomeration on the surface of an aluminized heterogeneous propellant since the dynamics of these agglomerates (detachment from the surface, transport in the chamber flow, burning, impact of aluminum oxide particulate on the nozzle which abrades the nozzle, and creation of an exhaust signature) is of critical importance to the performance of solid rocket engines.

PHASE I: In this phase the concept and general framework of a modeling/simulation code for the propellant should be established

PHASE II: In this phase a working code containing a full Graphical User Interface (GUI) (and post-processing) and capable of running on a multi-processor platform should be provided. The code shall predict the mechanical properties and agglomeration behavior of the propellant constituents with a minimum of empirical correlations.

DUAL USE COMMERCIALIZATION: Military application: In this phase a robust code capable of multimaterial simulations, including detailed prediction of macroscopic material behavior based solely upon constituent properties, should be provided. Commercial application: Would provide customers in the commercial world the ability of predicting packing fractions of various powder mixes and replace the current practice of extrapolation from an empirical data base.

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KEYWORDS: solid propellant, combustion, modeling, aluminum particles, packing

AF06-T013 TITLE: <u>Mechanized Skins for Morphing Aircraft Structures</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop novel integrated morphing skin and structure concepts that enable variable geometry aerodynamic surfaces that enable large scale area changes (on the order of 100%) while simultaneously maintaining a viable nonporous surface... The skin can be mechanized so as to use bending, rotating, translating, elongating, or contracting elements to achieve the desired structural reconfiguration needs at reasonable actuation levels. Integration of secondary characteristics, such as electrical conductivity, thermal stability, and self-sensing will provide a new generation of aircraft skins concepts for morphing structures. This topic will not support the development of new materials, but will instead focus on the development of skin/structure concepts that can exploit clever mechanical design in order to work within the limits of existing materials.

DESCRIPTION: A new generation of unmanned aircraft is being explored that has been coined “Morphing Aircraft. [1]” Morphing aircraft are unmanned systems that have the ability to change fundamental system performance characteristics (aerodynamic spectrum, visible spectrum, functional spectrum). An example is an unmanned aerial vehicle (UAV) that can change configurations from a high-speed dasher to an efficient loiterer. Virtually all shape changing concepts currently being pursued, and proposed for the future, need non-rigid skins working together with a mechanized structure [1]. In addition to being able to accommodate the mechanical shape change, these skins must maintain a smooth aerodynamic surface, load-bearing capabilities, and operate over temperature ranges typical of air vehicle flight.

There are several challenges to developing highly deformable skin concepts. First, there must be a fundamental material building block that has the basic desired characteristics. Some emerging materials, such as shape memory polymers and elastomers [2, 3], have some of these features. However, they need to be reinforced to maintain an adequate stiffness to resist out-of-plane deformations due to aerodynamic loading. This reinforcement must provide the necessary control over various properties such as Poisson’s ratio and plate bending stiffness while allowing large scale deformation. Possibilities for reinforcement involve novel mechanization concepts (e.g., tensegrity, scales [4]) and high strain fibers. In general, an anisotropic engineered material is required. The deformation can be triggered by electrical, thermal, photo or other means which is amenable to an operational environment. [5]. The integration of these actuation elements into the system is an additional challenge toward successful application of this technology.

PHASE I: Identify basic morphing mechanism concepts (scales, mechanized skins, etc) and the preferred deformation mechanism (i.e., bending, shear, and membrane) that will enable the desired control over the structural geometry (etc, large scale area changes, minimum surface deflections). Select and evaluate the type of materials needed (elastomeric sheets, high stiffness fibers, foams, etc.), the fabrication method used, and the optimal method to trigger the deformation (electric, thermal, photo, etc.)

PHASE II: Fabricate representative mechanized skins that demonstrate large area changes with minimal surface deformations, as well as material and structural stability at various states (e.g., loading condition, temperature, etc.). Also, measure the mechanical actuation power required to deform the skin to different states and to hold it (if required) at given positions. Finally, demonstrate the skin's ability to cycle (e.g., return to original state) and measure any hysteresis in the process.

PHASE III DUAL USE APPLICATIONS: Any air vehicle structure that requires active shape changing. Mechanized skins have broad commercial implications, ranging from enabling basic robotic functions (e.g., large rigid body motion), protective suits in adverse environments, reconfigurable dwellings, prosthetics, and others.

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KEYWORDS: Mechanization, polymers, foams, actuator, shape memory, morphing aircraft structures, flexible skins

AF06-T014 TITLE: Reduced Nonlinearity Superconducting Thin Films for Transmit and Receive Applications

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop high-power-handling films of high temperature superconductors (HTS) with improved linearity for use in microwave receivers and transmitters.

DESCRIPTION: High-temperature superconductor devices are being successfully employed in commercial wireless telephone base stations as receive filters. Even so, experimental evidence in agreement with theoretical predictions indicates that the intrinsic limit of the microwave nonlinearity and power handling of HTS films is being reached. The limit is imposed by d-wave symmetry in HTS materials and the associated nodes in the energy gap. HTS filters fabricated with present-day films, operating at the intrinsic limit, may not meet the linearity needs of proposed military receiver-transmitter systems. A recent theory of nonlinearities indicates one could improve linearity by growing thicker films. Intermodulation distortion is predicted to vary inversely proportional to the fourth power of the film thickness. Unfortunately, systematic efforts to increase film thickness have shown that film quality decreases as the HTS films become thicker, especially above 1 micron, with no improvement in linearity. Recently it was found that YBCO/CeO2 multilayer films can be grown and still maintain a high Jc value even for thicknesses in which a single-layer film would show significant degradation. These multilayer techniques can be beneficial to microwave applications due to the prospects for reduced nonlinearity with thicker films. The films are of interest not only for lower intermodulation distortion at low power, but also for high breakdown powers because of the potential for enhanced surface pinning of vortices.

PHASE I: Determine the best method to fabricate thick HTS films that maintain excellent microwave properties. A baseline YBCO thin film should be demonstrated with excellent microwave properties, e.g., low surface resistance and intrinsic nonlinearities as measured by intermodulation distortion.

PHASE II: Fabricate thick HTS films with thicknesses approaching several microns. Characterize the films for Tc, Jc and microwave properties, including low-power surface resistance, intermodulation distortion and breakdown power. Finally, demonstrate planar microwave filters which operate with improved linearity.

DUAL USE COMMERCIALIZATION: Military application: Military and commercial applications will include compact filters for receive and transmit operation in microwave frequency wireless systems. Commercial application: Military and commercial applications will include compact filters for receive and transmit operation in microwave frequency wireless systems.

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KEYWORDS: high temperature superconductors, superconductivity, microwave devices, microwave filters, YBCO

AF06-T015 TITLE: RF Polymer

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Investigate and develop novel polymer based materials that have relatively high dielectric permittivity and magnetic permeability (>5), and with low loss (loss tangent <10-3) at frequency above 1 GHz.

DESCRIPTION: A new generation of antenna designs will be needed to satisfy many advanced Air Force applications such as multispectral requirements, small footprint antenna for small platforms, and load bearing antenna structures. Properly designed radio frequency (RF) polymers with carefully controlled dielectric permittivity and magnetic permeability will be needed to enable these designs. These RF polymers should have non trivial permittivity and permeability values of above 5 and with low loss values above 1 GHz. Polymer nanocomposites have shown to be a promising approach to meet these properties goals. This solicitation will explore interesting materials concepts that will yield RF polymers with the stated properties goals and with processing characteristics that can yield large area films or structures for antenna applications.

PHASE I: Fabricate and Evaluate RF polymers based on proposed material and composite concepts to yield proof of principle data to substantiate the potential of these materials to yield large area films or structures, and with target goal properties above 1 GHz.

PHASE II: Based on Phase I results, further develop and scale up the proposed material system, focusing on the optimization the fabrication approaches to yield large area films and structures and meeting the properties goals of dielectric permittivity and magnetic permeability.

DUAL USE COMMERCIALIZATION: Military application: This materials will be used for widebandwith antenna systems with small footprints, conformal antenna and compact antenna for unmenned air vehicles (UAV). Commercial application: These polymers can be used in many wireless handheld devices such as cell phones and PDAs to yield more efficient communications between the units and base towers.

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KEYWORDS: RF polymers, controlled permeability and permittivity, large area film and structure fabrication methodology.

AF06-T016 TITLE: A Variable-fidelity Simulation Tool for Dynamic Non-linear Fluid/Structure Interaction Problems

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop technologies for increasing the aeroelastic stability of air vehicles that dynamically alter shape, either in discrete events or in continuous operation.

DESCRIPTION: The morphing of air vehicles is an important means for enabling vehicles to achieve a broader range of operational modes. Two concepts serve as useful examples: a hypersonic aircraft that dashes to a region of airspace and converts shape to enable long-endurance surveillance, and a flapping-wing, micro-air-vehicle (MAV), whose operation fundamentally changes in the presence of strong wind gusts and/or depending on whether forward flight or hover are desired. While quite different vehicle concepts, in both examples, shape change is constrained by structural flexibility and the potential loss of aeroelastic stability and/or control authority. Owing to the potential for dangerous loss of aeroelastic stability, technologies are needed to ensure that the in-flight shape changes are sound (flutter free for dash to loiter configuration changes and MAV robustness while landing in gusts). Currently, technologies do not exist in this area and need to be developed to overcome key challenges: (1) complexity of flow physics around dynamically altering geometries over a wide speed range; (2) predicting large structural deformations under dynamic loading; (3) uncertain environmental conditions, and (4) adaptive, real-time, stability-margin estimation. No computational methods exist with which to conceptualize how vehicles should safely shape change, let alone adapt that change during flight given current conditions. To resolve these modeling shortcomings, new technologies are needed to link highly energetic structures and flows in a framework suitable for both simulation and real-time decision-making. Activity should (1) resolve linkage issues that severely degrade modeling accuracy, even in benign environments; (2) address various forms of modeling and system uncertainty, and (3) enable modeling fidelity to be adjustable to permit safe, situational-dependent shape changes based on detailed pre-flight studies.

PHASE I: Develop and demonstrate an appropriate aeroelastic stability augmentation system for different morphing air vehicle concepts. Examine robustness of systems subject to reasonable levels of uncertainty.

PHASE II: Extend the work of Phase I to produce a robust framework by which complex geometries with arbitrarily large deformations and shape changes can be manipulated safely in a simulated operational environment.

DUAL USE COMMERCIALIZATION: Military application: Military applications include design of next-generation manned and unmanned aerospace vehicles specially highly maneuverable vehicles or configurations with joined or high-aspect ratio wings. Commercial application: Applications include design of invivo medical devices with focus on loads and deformations imposed by blood flow, and design of micro-air vehicles where fluid/structure interactions are anticipated.

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KEYWORDS: aeroelasticity, stability, fluid/structure interaction, morphing, hierarchical computing, flapping wing flight

AF06-T017 TITLE: Mechanically Adaptive Materials for Morphing Aircraft Skins

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Investigate and develop novel materials that enable large in-plane structural deformations (on the order of 100%) with minimal decrease in out-of-plane stiffness, while maintaining the necessary secondary characteristics, including electrical, barrier and thermal performance; and thereby providing material-based solutions to a new generation of aircraft skins for morphing structures.

DESCRIPTION: This topic is focused on developing skin materials that can be used in Morphing Aircraft concepts. Morphing Aircraft [1] require the air vehicle systems to have the ability to change fundamental system performance characteristics either in the aerodynamic or the functional domains. An example is an unmanned aerial vehicle (UAV) that can change configurations from a high-speed dasher to an efficient loiterer. Such a transformation requires the wing to change its dimension and aero-surface area by almost 100%. Virtually all shape changing concepts currently being pursued and proposed for the future need unique flexible skins working together with a mechanized structure [1]. This topic will focus on developing new skin materials that meet the requirements in these shape changing concepts. In addition to being able to accommodate the mechanical shape change, these skins must maintain a smooth aerodynamic surface and load-bearing capabilities. Furthermore, the skins are envisioned as an integral part of the system¡¦s payload such as containing embedded antennas that tailor operational frequency spectrum on demand. Major challenges include the development of new polymers, auxetic foams, organic-inorganic hybrids and/or nanocomposite concepts with dynamic variable stiffness (Ez/Ex, Ez/Ey > 105) that span operation temperatures (-40C to 150C) and provide large area (m2) films with aerodynamic surfaces. Reversible transition between states must expend minimal energy (power) density from the system; and the maintenance of the end-states (initial and final) must not require any energy expenditures. Other challenges include development of material concepts to provide necessary health monitoring (prognostics) and the ability to execute real-time fine-structure control, such as inherent piezoresistivity or piezoelectricity.

PHASE I: Evaluate proposed material (polymers, auxetic foams, hybrids, nanocomposites) and control stimuli (light, current, pressure, etc.) to yield proof of principle data to substantiate the potential of dynamic (controllable) variable stiffness (Ez/Ex, Ez/Ey > 104) over an environment operation temperature range of 0 to 100C. Demonstrate ability to in-situ monitor mechanical state of material concept. Finally, determine scale-up feasibility to provide large area (m2) films.

PHASE II: Further develop the proposed material system, focusing on the optimization with regard to expanding modulus (105) and operation (ƒ´T ~ 150C) range and reducing the necessary energy budget. Develop the manufacturing processes / methods to produce the material in various forms with necessary process controls. Finally, fabricate a representative structural component (i.e., plate, shell, etc) with the novel mechanically adaptive skins.

DUAL USE COMMERCIALIZATION: Military application: Enable Morphing Aircraft with multiple configurations for multimode operation capability. Commercial application: Mechanically adaptive materials have broad commercial implications, ranging from enabling various robotic designs to medical devices for non-invasive surgery.

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Toensmeier, P.A., ¡§Morphing Aircraft Could Bring Multi-Role Capability to Next Generation Aircraft, Aviation Week, May 2005, pg 72-73

KEYWORDS: polymers, foams, auxetics, actuator, shape memory, morphing aircraft structures, flexible skins, nanocomposites

AF06-T018 TITLE: <u>High-current Field Emitter Arrays for Directed Energy Weapons</u>

TECHNOLOGY AREAS: Sensors, Weapons

OBJECTIVE: To demonstrate large total current (> 1 Amp) from a field emitter array (FEA) that is suitable for supplying the electron beam inside a microwave vacuum electron device.

DESCRIPTION: The promise of extremely high current densities with no required external energy source (such as a heater, primary electron beam, or intense light source) has motivated the pursuit of a robust, reproducible field-emission-based electron beam. Today's field emitters can routinely achieve anywhere from 10 microamps to a few milliamps of current from a single emitter tip. In addition, such field emitters can be packaged into arrays with anywhere from 1 million to 100 million tips per square cm. Thus far, however, emission non-uniformity has prevented such FEAs from achieving large total currents (> 1 Amp). The goal of this research is to find novel stabilization techniques in order to reduce the variation in the current from emitter to emitter, thereby allowing high total current operation. Field emission currents on the order of 1 Amp and greater will enable a new generation of instant-on microwave devices of sufficient output power for military application.

PHASE I: Develop and test a suitable scheme for stabilizing the current emitted by each site in a FEA with an emission area of greater than 1 sq mm. This stability should enable the array to, at a minimum, avoid self-destruction due to overcurrent at a single location.

PHASE II: Implement and perfect the scheme developed in Phase I in order to build and test a field emitter array with an area of approximately 1 square centimeter that can supply > 1 Amp of total current (either pulsed or DC). Ideally, the emission uniformity will be such that the current variation from site to site is less than a factor of 2.

DUAL USE COMMERCIALIZATION: Military application: Such FEAs may supply the electron beam required in next-generation microwave devices suitable for radar, communications, and, eventually, high power microwave devices for Directed Energy applications. Commercial application: These FEAs may then be scaled appropriately to provide the electron beam for flat-panel field emission displays, medical x-ray sources, and ionization/neutralization sources for spacecraft propulsion.

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KEYWORDS: Field emission, cathodes, microwaves, field emitter arrays, current control, vacuum microelectronics

AF06-T019 TITLE: <u>Nanocatalysts for Hydrocarbon-Fueled Rocket Based Combined Cycle (RBCC) Engines</u>

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop nanocatalysts capable of increasing the heat sink capacity and accelerating the rate of combustion in regeneratively cooled engines.

DESCRIPTION: One of the primary challenges facing Rocket Based Combined Cycle (RBCC) propulsion systems for spacelift is establishing a fuel system that is compatible with both the rocket and supersonic ramjet (scramjet) portions of the flight. Future concept vehicles employ regeneratively cooled engines which rely on the fuel to absorb engine heat loads to ensure survival of the engine structure under conditions where stagnation temperatures can exceed 5000° F. Using the fuel to absorb heat and burning the hot fuel efficiently keeps the heat in the cycle and is termed regenerative cooling. For hydrocarbons, deliberate reactions of the bulk fuel (such as cracking) significantly enhance the heat sink capability of the fuel - leading to the term "endothermic fuels". These cracked products, hydrogen, acetylene, and ethylene, typically improve combustion which is important in the scramjet portion of the cycle where the combustion reaction must be initiated and completed in an extremely limited residence time (~ 1 millisecond). Wall-mounted catalysts are currently used in engine cooling passages. Use of wall-mounted catalysts puts the catalyst at the fuel/structure interface for best heat transfer performance. Another possibility is the injection of a soluble catalyst into the fuel either during or prior to engine operation. The use of a soluble catalyst is preferred because it reduces the need to develop specialized components and can be applied to a variety of platforms and configurations. Soluble catalysts have the additional advantage of being transported to the combustion region and could therefore also be used to increase the rate of combustion. Advanced catalysts developed specifically for RBCC conditions are sought. The catalyst should be capable of accelerating the rate of combustion of hydrocarbon fuels and increasing the heat sink capability of these fuels by enhancing the formation of desirable products (hydrogen, ethylene, acetylene) while minimizing the formation of undesirable products (methane, solid carbon or "coke"). The catalyst particles should be soluble in the RBCC fuel, active at levels of 0.1% by weight or less, and small, on the order of 1-100 nm, to not interfere with engine operation.

PHASE I: Identify key physical and chemical phenomena associated with use of the nanocatalysts in RBCC engines and develop an experimental approach that demonstrates the important characteristics. Provide preliminary data sets to support the activity of the catalysts for the targeted applications.

PHASE II: Develop a comprehensive experimental and theoretical program that demonstrates the improvements in the areas of heat sink capability and combustion acceleration and establishes the mechanisms responsible for the catalytic activity. At a minimum, the catalyst(s) should be well-characterized, structurally and mechanistically understood, and capable of being produced reliably.

DUAL USE COMMERCIALIZATION: Military application: The offeror will apply these new catalysts to develop RBCC propulsion systems leading to improved standoff missile capabilities for rapid response and global strike capability in manned systems. Commercial application: Commercial benefits include reduced time, risk, and cost for developing a propulsion capability for commercial space flight.

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KEYWORDS: reusable rocket, hypersonic, scramjet, catalysts, combustion, supersonic combustion, hydrocarbon fuels, nanotechnology

AF06-T020 TITLE: Image-based Tracking Algorithms for Unmanned Aerial Vehicles

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop image-based tracking algorithms for a network of unmanned aerial vehicles (UAVs) that are providing surveillance of both human and vehicular targets in an urban environment.

DESCRIPTION: Maintaining global track quality, especially track continuity, is a significant challenge for targets of interest that become occluded. The situation is complicated when clutter or tracks that are not of interest are in proximity of the desired target. These situations are typical when attempting to track dismounted targets in an urban environment. Given the availability of image-based sensors (EO/IR) on UAV platforms, a multi-target video tracking system with global track fusion and feedback can be developed to mitigate these issues. Furthermore, because current UAV hardware is unable to process, in real time, all of the imagery provided by its sensors, video processing resources must be allocated/prioritized appropriately. Key aspects of this multi-target multi-sensor tracking application include: (i) video processing and related resource management for each UAV, (ii) local track generation and maintenance for each UAV, (iii) correlation and fusion of local track data at each fusion node, and (iv) feedback from each fusion node to its associated local trackers (i.e., the UAVs) and other fusion nodes in the network.

PHASE I: Explore architectures that effectively fuse local track information, provide feedback to the local trackers, and potentially re-route the UAVs to improve global tracking performance. Develop innovative algorithms and software to determine optimal allocation of video processing resources.

PHASE II: The most promising algorithms and architectures from the Phase I effort shall be implemented and evaluated. Perform a detailed analysis and final design via simulation studies using synthetic data. Validate performance on real imagery datasets incorporated into the simulation environment from Phase I.

DUAL USE COMMERCIALIZATION: Military application: Accurate and efficient surveillance will provide a significant force multiplier to DoD operations in these environments. Homeland Defense and law enforcement will also benefit from this technology. Significant potential exists for traffic monitoring/management (e.g., detecting traffic congestion or accidents on highways) and for disaster management and recovery. Finally, real-time medical imaging involving moving biological systems may be enhanced by the techniques developed through this research.

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KEYWORDS: multi-target tracking, urban dismounts, video processing, sensor fusion, unmanned aerial vehicles

AF06-T021 TITLE: Flapping Wing Aerodynamics and Control for Maneuverable Hovering Micro Air Vehicles

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Demonstrate a flapping-wing micro air vehicle capable of controlled hover and cruising flight in a representative disturbance environment.

DESCRIPTION: Micro Air Vehicles (MAVs) – typically unmanned aerial vehicles (UAVs) with wingspan on the order of 15cm or less – have been demonstrated as feasible in steady level flight, and to a lesser extent in maneuvering flight. The low-Reynolds number flow fields associated with MAVs are characterized by flow separation, unsteadiness and viscous interactions to an extent not encountered for air vehicles of larger size. Lift to drag ratio and airfoil efficiency are degraded by the inability of laminar boundary layers to remain attached. Sensitivity to wind gusts is high, in part because gust speeds are comparable to vehicle flight speeds, in part because the unsteadiness associated with gusts has profound impact on vehicle aerodynamic response, and in part because vehicle inertia is so low. The need to rigorously study flow phenomena at low Reynolds numbers was pointed out in the 2002 OSD Roadmap for UAVs. While the challenge of increasing MAV range and endurance is perhaps best met by improvement in electrical batteries, multifunctional materials and other system enablers, the improvement of aircraft handling, maneuverability and gust tolerance at the MAV scale is predicated on integrated aerodynamic lift, propulsion and control which can adequately manage massive, time-dependent separations.

The ability to hover in a controlled, efficient manner is important to many MAV missions, such as urban surveillance, where the MAV would for example need to execute a precision hover outside a building window, and possibly perch on a window sill. But hovering is only useful if it can be sustained in the presence of winds, such as those in the wake of the building itself. Fast temporal response is more important than classical measures of aerodynamic efficiency such as lift to drag ratio. The vehicle requires a system of lift and thrust production that can quickly respond to flow field changes. Such a system has not been demonstrated. The ducted fan concept fails because of separation from the fan lip in cross flow, whereas a micro-helicopter would be limited by blade stall.

Recently there has been broad interest in flapping wings as an unconventional means of integrating lift, propulsion and control. Studies of examples in nature, such as fruit flies and hawk moths, have revealed spectacular performance gains from exploiting separated vortical structures and the delay of leading edge vortex shedding.

Besides producing improved lift and propulsion, phase-sensitive wing rotations and translations can modulate average lift and pitching moment coefficients, introducing a mechanism for maneuvering, or for responding to gusts.

For flapping to be useful for practical MAVs, fundamental research is necessary to extend the existing knowledge of unsteady wing aerodynamics to include massive separation at low Reynolds number, on the order of 10^4, to include rigorous correlation between flow field dynamics, vehicle aerodynamics loads, and consequent flight mechanics. In particular, it is important to verify conjectures regarding the Reynolds number dependency of lift-enhancing mechanisms common to insects, such as delayed stall; to assess aeroelastic effects, such as whether a rigid wing is inferior to a suitably designed flexible wing in inhibiting unfavorable separation and exploiting time-dependent effects; and to formalize design criteria for flapping wing configurations. Unconventional sensors may also be necessary – such as local skin friction sensors (to detect separation), instead of Pitot tubes and angle of attack vanes.

A practical flying vehicle is only realizable if the intricacies of wing articulation and the vehicle flight control scheme are made transparent to the operator. The effort should culminate with a vehicle that can hover, holding position in a range of gust and disturbance conditions such as cross-flowing jets, and transition to cruise.

Physical dimensions of candidate MAVs will be similar to those of comparable fixed-wing configurations in prior studies: a nominal cruise speed of 30 ft/s, and wingspan of no greater than 15 cm, with preference to even more aggressive miniaturization.

PHASE I: Quantitatively identify (1) the relationship between wing kinematics, flow field behavior and aero loads; and (2) structural, mechanical, and fabrication-process issues for design and performance prediction of hover-capable MAV of <15cm span. Flight-demo hover-capable prototype.

PHASE II: Develop and validate a simulation environment with high-fidelity modeling of flapping-wing MAV flight physics. Develop, characterize, and open-loop flight demo a prototype flapping wing MAV with the ability to maneuver, land, take-off, hover and cruise in crosswinds of 20 ft/s. Identify sensors, actuators, feedback mechanisms and processing necessary for autonomous flight.

DUAL USE COMMERCIALIZATION: Military application: Unobtrusive (ISR) in urban environments. Battle damage assessment. Tagging, tracking and locating (dismounts, automobiles). Cave search. Perch-and-stare on trees and window sills. Commercial application: Search for victims in collapsed buildings (earthquake and hurricane damage), pipeline/powerline inspection, detection of forest fires, urban policing.

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KEYWORDS: micro air vehicle, low reynolds number, unsteady, separation, separated flow, pitching wing, flapping, hovering, flexible wing

AF06-T022 TITLE: High-Power Millimeter-Wave Micro-Sources for Communications & Radar Dominance

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Create new extremely compact & lightweight millimeter-wave radiation sources generating hundreds of watts (peak power).

DESCRIPTION: Today's military communications and radar communities require higher frequency, greater power, smaller size, lighter weight, cheaper cost, cooler temperature, superb reliability, larger bandwidth, and highly efficiency. Taken together, these goals present an awesome challenge to microwave source researchers. At present, microwave vacuum electronic devices (MVEDs) such as traveling-wave tubes (TWTs) admirably handle kilowatt power levels for tens of GHz. Although their reliability and efficiency are excellent, their prices rise dramatically as one moves to higher frequencies. Solid-state devices offer no viable solution in this parameter regime because they are limited in power (< 1 Watt) at W-Band. Fortunately, very promising seminal work has recently emerged that seeks to use solid-state's micro-fabrication techniques to create ultra miniature MVEDs for high frequency operation. In accomplishing this, investigations will be required of new types of conductor, dielectric, and vacuum window materials (including composites and coatings) that are better suited to such micro-scale devices. The design of such micro-sources will be guided by detailed 3-D relativistic electromagnetic computer modeling of their physics from the emission of the driving beam, through the generation of mm-wave radiation, to the recapture of the spent beam.

PHASE I: Conceptualize, design and model a miniature MVED that will be capable of generating up to hundreds of watts (peak power) at a frequency of about 95 GHz (W-Band).

PHASE II: Use state-of-the-art deep-etch micro-fabrication technology to fabricate a complete, working micro-MVED with the above parameters.

DUAL USE COMMERCIALIZATION: Military application: Such a device will find immediate use in military communications, radar, non-lethal warfare systems and on satellite, mobile, and unmanned aerial vehicle (UAV) communications. Commercial application: Higher frequencies will expand the bandwidth of individual high-cost communications satellites. Higher frequencies are also more directional and can enhance point-to-point security.

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KEYWORDS: micro-fabrication, vacuum electronics, millimeter-wave sources

AF06-T023 TITLE: Aluminum Cladding Replacement

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop methods and procedures to redeposit cladding materials on aircraft outer mold line.

DESCRIPTION: The aging U.S. Air Force legacy aircraft fleet (e.g., KC-135, C-130, F-15, etc.) has a well-documented corrosion problem. During both depot and field repair operations the coating system is removed using mechanical and chemical stripping methods. The stripping methods also remove some of the metallic cladding. On older AF aircraft the cladding material has been completely removed. The metallic cladding was deposited on the aluminum frame during the initial manufacturing to provide galvanic corrosion protection. The removal of the cladding during paint stripping operations makes the underlying high strength aluminum alloy, such as AA 2024-T3 and 7075-T6, more prone to corrosion. Currently there are no methods to replace the cladding without removing the skin of the aircraft.

Recently results have been published demonstrating enhance corrosion protection of aluminum alloys using amorphous alloys as cladding materials. These materials have shown enhanced corrosion properties that rely on the amorphous state of the cladding as well as transition element and rare earth element additions.

This project will develop deposition processes that can be used to deposit cladding materials on aircraft. The cladding system should be easily depot applied to provide active corrosion protection for the underlying high strength aluminum alloy. The cladding materials should also be compatible with existing aircraft coatings. This project should also investigate new cladding materials such as amorphous alloys.

PHASE I: Evaluate both new cladding materials and application methods on AA 2024-T3 and 7075-T6 coupons. Utilize modeling and simulation to held guide the evaluation process. Evaluate the corrosion protection provided by the cladding material.

PHASE II: Down select to the most promising cladding materials and application methods. Prepare samples on AA 2024-T3 and 7075-T6 samples that accurately portray the complex geometry present on aircraft. Conduct through corrosion and mechanical testing.

DUAL USE COMMERCIALIZATION: Military application: This technology will aid in the sustainment of legacy aircraft with aluminum skins. Commercial application: Novel cladding materials and applications methods will be of use for civilian aircraft as well as in applications where aluminum is used but cladding cannot be present during fabrication.

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KEYWORDS: corrosion, cladding, aluminum alloys

AF06-T024   TITLE: Random Radar

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: A small, lightweight system (that can be carried by a soldier (<40lbs) or on a pickup truck or a C130--<250lbs)) that will provide excellent images of structures/people interior to a building. We seek a system that cannot be jammed and whose operating bandwidth provides not only suitable round trip propagation (including structure penetration) strength but also which can be used covertly given a sophisticated adversary.

DESCRIPTION: The problem we are addressing in this effort is the detection of hostile personnel and material behind building walls using portable ground based radar, or airborne radar providing images through roof structures. The goal is to develop a radar system to detect and characterize personnel and equipment in severe urban clutter and through external and internal building walls. Critical situations involving terrorist attacks, hostages, and natural catastrophes are expected to occur with greater frequency in the coming years. Law enforcement practitioners and military personnel will need the ability to perform through-the-wall surveillance (TWS), not only to covertly detect, locate, and track individuals within buildings, but also to characterize a building's internal features in order to identify hiding places. The purpose of the proposed research and development project is to provide military personnel with real-time, dynamic, and accurate information on such types of critical situations. Timely information will significantly enhance the decision-making process.

Radar-based electromagnetic technologies have been determined to offer the greatest potential for penetrating a variety of building materials and providing good range resolution by appropriate choice of operating frequencies (50MHz through 10GHz and 0.10 milliwatts/sqcm)and bandwidth. Current radar technologies for through-wall imaging are bulky, stand-alone, clearly visible, and relatively immobile stand-off systems that require superior technical skills to deploy, operate, and interpret. In addition to being unable to probe the inner rooms of a building from their usual exterior placement, these systems also do not provide suitable effectiveness in situations involving “room clearing” and hostage rescue, both of which need dynamic acquisition and interpretation. Furthermore, the majority of currently available radar systems use signals that are easy to detect and somewhat easy to jam. These systems also produce signals that may interfere with other friendly systems

PHASE I: We seek a concept for a small, lightweight system that will provide excellent images of structures interior to a building, that cannot be jammed, and which can be used covertly given a sophisticated adversary

PHASE II: The development of a prototype leading to high fidelity estimates and critical laboratory tests of proof of the fundamental principles involved in the radar operation.

DUAL USE COMMERCIALIZATION: Military application: A prototype that can provide a vehicle for T&E endorsement.

Commercial application: A system such as described above would provide customers in the commercial world the ability to inspect various products. It would also be helpful to the Department of Homeland Security.

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KEYWORDS: radar, random waveform, noise

AF06-T025 TITLE: Self-Healing Adhesives and Composites for Aerospace Systems

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To implement the self-repairing capability in (a) structural adhesive to extend fatigue and service life of bonded joints and in (b) composite tanks to eliminate leakage due to microcracking of resin matrix, using innovative concepts of self-healing polymers.

DESCRIPTION: Bonded joints are prevalent to almost all aspects of aerospace systems of varied applications, ranging from tiny heat sink attached to computer chips to large structural components of aircraft and spacecraft. The adhesives in bonded joints, being pervasive to many applications, are exposed to a wide range of service loading conditions, such as thermal cycling in space environment, static creep and mechanical fatigue imposed by structural joint configurations, and residual stress due to mismatch of thermal expansion between adhesive and substrates. All these service loading conditions are the cause of damage in adhesives limiting its structural performance and other functional attributes. In this respect, polymeric adhesives with self-repairing capability to suppress service-induced damage and cracking in particular provides a promising potential in extending operational life of bonded joints. Within the same context, the self-repairing capability in composite cryogenic tanks is also highly desirable to suppress (or perhaps eliminate) leakage due to microcracks in polymer matrix of fiber-reinforced composite plies. These microcracks are caused by the same service loading conditions mentioned earlier.

There remain many technical challenges to incorporate the self-repairing concepts in the adhesive of the bonded joints as well as the resin matrix of fiber-reinforced composites. In case of bonded joints, the damage or cracking initiates at the free-edge interfaces between the adhesive and the substrate, due to the presence of high stress concentration. The success of the concepts will solely depend on initiating the healing or repairing phenomena at the critical locations of bonded joints or composite cryogenic tanks. This will involve devising appropriate chemical reaction for healing of polymers and delivering or dispersing the healing stimuli where needed. The inspiration for self-healing materials can be found in biological systems in which damage triggers an autonomic response for structural adaptation and replication. Recent advances in novel multi-functional materials present a new opportunity for research in this direction. One representative example is a breakthrough achieved with self-healing epoxy resins and their composites (White, 2001). The approach was based on in situ matrix generation via embedded microcapsules of healing agents and catalytic chemical triggers.

PHASE I: Demonstrate the concept in bonded joints and fiber-reinforced resin composites. Utilize simple configurations under static and fatigue loading to quantify the healing performance. Identify the systems of healing agents and catalysts that are environmentally stable and compatible with the system.

PHASE II: Optimize the parameters influencing the healing mechanism under realistic service conditions. Reduce the healing time yet retaining the structural integrity. Assess the healing performance of adhesive in presence of high stress concentration. Assess the feasibility of preparing composite prepreg based on the same type of self-healing polymers developed for adhesive application.

DUAL USE COMMERCIALIZATION: Military application: Conduct extensive manufacturing and testing program for utilization of the self-healing phenomena to enhance the service life of adhesive joints as well as structural composites in large scale. Commercial application: For use in aerospace and electronics industry, assess the potential of life cycle cost saving that the technology potentially will offer. Perform their cost analysis and affordability validation.

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KEYWORDS: self-healing polymer, adhesive joints, fiber composites, damage tolerance

AF06-T026 TITLE: Nanomaterial Photovoltaics

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Develop inorganic materials containing nanostructures for ultra-high efficiency photovoltaic cell applications

DESCRIPTION: Quantum confinement has been shown to alter optoelectronic properties in semiconductors, including size-dependent bandgaps in nanoparticles. As a result, semiconductor nanostructures in a range of sizes are capable of absorbing a large portion of the solar spectrum, an advantage for increasing efficiency in solar cells. Nanoparticles or quantum dots have been embedded in a conjugated polymer matrix to produce photovoltaic devices with the polymer responsible for transport of hole carriers to an electrical contact. However, low hole mobility in conjugated polymers limits the collection of these charges and photovoltaic device efficiency. In addition, most polymers suffer deleterious effects when exposed to the types of ionizing radiation found in the space environment, where arrays of photovoltaics are relied upon for power generation. Higher efficiency solar cells are needed to reduce solar array mass, stowed volume, and cost for AF space missions. Conventional crystalline multijunction solar cells are currently limited in efficiency to 30% air mass zero (AM0) by the complexity of adding more junctions to increase absorption of the solar spectrum, and the necessity to match lattice parameter and current for each junction. Nanostructured materials and devices are sought that effectively absorb a large portion of the solar spectrum, facilitate separation of electron and hole pairs while minimizing the recombination rate, and conduct those charges to an external circuit for efficient conversion of solar to electrical energy. The proposed device materials should be inorganic or robust enough to withstand the ionizing radiation and extreme temperatures found in Earth orbit.

PHASE I: Perform a feasibility study through modeling and experimental demonstration of a nanostructured photovoltaic device. Determine theoretical efficiency of device design.

PHASE II: Fabricate a prototype of the nanostructured device. Identify physical effects resulting in performance limitations and develop approaches to optimize device performance.

DUAL USE COMMERCIALIZATION: Military application: Radiation resistant solar cells with >40% efficiency are in high demand for commercial and military satellites. Commercial application: Comm'l of high efficiency solar cells is extremely likely for space and terrestrial applications. Rad-hard solar cells with >40% efficiency are in high demand for commercial and military satellites.

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KEYWORDS: solar cells, photovoltaic cells, nanomaterials

AF06-T027 TITLE: Communication Analysis for Enhanced Team Performance in the AOC

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Create innovative, real-time communication and collaboration performance measures for a dynamic command and control environment.

DESCRIPTION: Today's network centric battlefield relies heavily on teams of warfighters operating remotely and often asynchronously with unknown teammates to carry out complex missions, coordinate command and control (C2), or make high-tempo decisions. These activities are conducted by the team as a unit and thus, assessment must also be conducted at the team level. In the past, decision making in C2 environments was constrained by limitations in information flow. In contrast, current and future environments must contend with the inverse problem: assuring that systems and operators manage large amounts of information efficiently and effectively. When team interactions are highly interdependent, system-wide error can occur as the results of a single weak link in the system. As systems grow in size, complexity, and interdependence, system vulnerabilities can also magnify increasing the possibility of system failure. Without the ability to skillfully manage information, coordination becomes error prone and mission success could suffer. Consequently, training decision makers to coordinate and collaborate effectively in these environments is critical. Unfortunately, in most C2 training environments, it is difficult to assess how well an individual or group of individuals is performing, in real time, without significant subjective assessment. Typical solutions to this problem involve time-intensive techniques that are based on observation, but are one step removed from actual data streams. How can we deduce the cognitive state, or the current level of expertise of the war-fighter directly from operational or training data? Some of the best data for assessing situation awareness, decision making, and leadership in team settings are also the least used. Communications – in a variety of forms – are ubiquitous and easy to capture. Communications reveal the continuous struggle to maintain situation awareness, make sound decisions, and coordinate with teammates when stakes are high and time is scarce. However, it has traditionally taken days or weeks to analyze these data and assess performance using them. As a result, communications analysis has become largely a research activity. Such research has produced valuable insights into the structure of expert knowledge concerning military operations, and patterns of discourse in successful teams. However, it is unclear how the approaches used in these studies relate to other performance metrics in the contexts of interest (e.g., observer based or simulation derived metrics). Assessment of large team performance and vulnerabilities in social networks is needed in real-time or even in a predictive mode in order to monitor and intervene to prevent such failure. A comprehensive approach to performance measurement that includes both embedded objective and observer-based subjective approaches to communications analysis would be highly beneficial for improving information flow in dynamic C2 environments. This approach leverages research in social networks and team performance and techniques for exploiting patterns in rich behavioral data to generate methods and tools for the automatic extraction and interpretation of social networks in teams.

PHASE I: Investigate existing and candidate performance measurement tools in a specific C2 environment. Formulate a measurement technique/application/methodology that will help diagnose operator performance based on communications analysis. Demonstrate the validity of this approach in a bounded context.

PHASE II: Build a functional prototype of a performance measurement system that integrates behavioral and communications metrics.

DUAL USE COMMERCIALIZATION: Performance measures utilizing information on communications flow & content have application in any C2 environments. Specifically, resulting measurement techniques can be applicable in operational environments such as law enforcement dispatch control centers, emergency management, hospitals, or any environments where measuring team communication is important. This technology will address both training enhancement through focused assessment of team interdependence and also overall operational effectiveness.

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KEYWORDS: team Performance measurement, communications analysis,
network centric warfare, human systems integration, team training, information management

AF06-T030 TITLE: <u>High-Resolution Wide-Dynamic-Range MEMS-Based Closed-Loop Adaptive Optics System</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop closed-loop adaptive optics system for wide-dynamic range aberration control with high-resolution micromachined electro-mechanical systems (MEMS) mirrors.

DESCRIPTION: An emerging generation of deformable mirror (DM) technologies based on (MEMS) manufacturing techniques is resulting in DM components with capabilities exceeding those of conventional DMs while, at the same time, reducing cost, weight, and electrical power requirements. Large throw, high-pixel-number MEMS DMs are an enabling technology that may enable the development of optical systems with inherently large time-dependent aberrations or high-spatial-frequency aberrations. These include systems based on large lightweight primary mirrors[1], systems involving propagation of laser light through extended atmospheric turbulence[2], systems that operate with large dynamic aberrations associated with varying field angles or object distances[3], ophthalmic instrumentation [4], and multi-conjugate adaptive optics[5]. These advances in DM components will challenge the capabilities of closed-loop adaptive optics techniques developed to operate with conventional deformable mirror systems. While conventional DM devices operate with a few microns of stroke, up to 1,000 control channels, and frame rates up to 1 kHz, novel MEMS-based high-resolution DMs could be capable of up to 40 microns of stroke, up to 1,000,000 control channels, and frame rates up to 100 kHz (Generally, a given MEMS DM does not display simultaneously all of these capabilities). Consequently, full utilization of the MEMS DM capabilities poses new challenges for wave front sensing and control systems.

Implementation of DMs into optical systems requires some method for measuring the system optical performance and the generation of control signals to optimize the DM surface. The increased resolution, speed and stroke of emerging MEMS-based DMs create new challenges for these control systems. In particular, wave front sensor (WFS) technologies may need to measure large aberrations and control systems may need to operate at very high speed with the increased number of control channels. The specific nature of aberrations can vary among applications including large range, low-spatial frequency aberrations such as is the case for field-angle-dependent aberrations, and lower-range, high-spatial-frequency aberrations such as is the case for extended atmospheric aberrations.

Various techniques have been utilized for measuring the optical system performance and generation of control signals. These include wave front measurement with technologies such as Shack-Hartmann sensors and interferometry as well as metric optimization techniques [2]. Image metric optimization techniques offer certain advantages, such as minimizing complexity, but have not been explored much for applications involving extended objects and large aberrations.

In order to significantly advance the state-of-the art and to be useful for DOD and commercial applications, an adaptive optics system with the following features is desirable: A MEMS-based DM with large throw and/or high spatial resolution, a real-time control system based on wave front sensing or image metric optimization, robust operation in the presence of large aberrations and extended object scenes, and at least one kilohertz closed-loop operating bandwidth.

PHASE I: Design and demonstrate an architecture that is consistent with the technical goals articulated above. Develop an initial system design and then, based on this design, develop a laboratory-scale system that demonstrates the architecture feasibility.

PHASE II: Use the Phase I results to build, test, and integrate the adaptive optics system with a state-of-the-art optical system requiring this technology. This includes optimization of the adaptive optics system to function with the specific optical system, achieving compatibility with regard to operating speed, OPD range, and resolution as well as optimization of control algorithms.

DUAL USE COMMERCIALIZATION: Military application: This is potentially an enabling technology for laser communications and large-aperture ultralightweight airborne and space-based optical imaging systems. Commercial application: Aberration compensation for extended-range high-data-rate laser communications, retinal imaging, optical tweezers, remote imaging for agriculture monitoring, traffic management, and law enforcement

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KEYWORDS: adaptive optics, wide-dynamic-range wavefront control, image metric optimization, wavefront sensing, wavefront control

AF06-T031 TITLE: Meta-Information Visualization for Preparation and Prediction

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and evaluate methods for visualizing information and meta-information to support decision making in a complex environment.

DESCRIPTION: The Intelligence Preparation of the Battlespace is an example of a process for providing predictive and timely intelligence to planning and execution operations (Satterly et al., 1999). Such processes help to direct Intelligence, Surveillance, and Reconnaissance (ISR) collection, exploitation, analysis, and dissemination tasks that support operational commanders by focusing on the ability to provide time-sensitive, relevant, credible information to support aerospace operations in dynamic environments. Tools and systems developed to support these systems must address the management of significant volumes of data, which must then be transformed into actionable intelligence. However, these systems often fail to account for how information is qualified - the information's relevant "meta-information" such as recency, uncertainty, and pedigree. Various methodologies have been used for ensuring that these kinds of information needs are met. One such methodology has been used to develop Work-Centered Support Systems (WCSS) (Scott et al., 2004). In developing WCSS and other such complex user interfaces across a number of domains, some basic issues have been raised about the best way to visually encode information for different work domains. In particular, are there arguments to be made about how best to visualize information to improve its discriminability, visibility, salience, and/or conspicuity (Thomas-Meyers, in press)? How might these features be tied to specific needs in the work domain? How might these techniques interact? What are the impacts of being able to guide attention to particular visual features for understanding and processing information in context? Prior and existing efforts to develop meta-information visualization systems have focused primarily on identifying meta-information needs and on systematically exploring possible display techniques (Pfautz et al., 2005; Basapur, Bisantz, & Kesavadas, 2003; Pang, Wittenbrink, & Lodha, 1997; Wittenbrink et al., 1996). This effort will focus on developing both information and meta-information visualization techniques for supporting the processes such as invision power board (IPB), particularly focusing on methods for improving the conspicuity of important information while decreasing the distractions caused by unimportant information. It could include the development of a system for constructing and testing visualization methods in the context of an IPB or other support tool. It should involve an to the systematic evaluation of visualization techniques in realistic environments (and, where necessary, more constrained situations) using established metrics (e.g., response time, accuracy, user trust (Lee & Moray, 1994), improved situation awareness (Endsley & Garland, 2000)).

PHASE I: Identify dimensions for portraying meta-information in a demonstration domain. Develop a controlled methodology for eval. that include metrics for assessing utility of each dimension and performance on visual attention tasks.Demonstrate the validity of these metrics with regard to decision-making.

PHASE II: Develop and implement methods for effective representation of critical information and meta-information. Formally evaluate visualization techniques in the context of a specific, sponsor approved domain using the approach identified under Phase I. Implement software for marrying display techniques to real or representative data sets in that domain.

DUAL USE COMMERCIALIZATION: Military application: Data visualization strategies & tools for info/meta-information to be applied to real-time, dynamic decision-support applications. Commercial application: Others include: state & local government emergency response systems, weather impact monitoring systems & financial industry (investment decision-making & risk management).

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KEYWORDS: intelligence preparation of the battlespace, information visualization, meta-information, work-centered support systems

AF06-T032 TITLE: Theory of Optical IMU Aiding; Loose, Tight, Ultra-Tight Optical Flow Coupling to Inertial Navigation Systems

TECHNOLOGY AREAS: Air Platform, Sensors, Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Given the success in developing ultra-tight coupled GPS/INS systems, develop and characterize similar constructs for INS aiding using optic flow measurements derived from onboard sensors.

DESCRIPTION: One of biggest concerns that the Air Force has today is how to perform precision navigation without GPS. Using inexpensive onboard passive electro optical (EO) sensors, it is possible to estimate self-motion, also known as ego-motion. Optic flow techniques exist to estimate the apparent motion in video sequences. Given the optic flow estimate, it is possible to characterize the observed motion in the video sequence induced by the sensor’s motion. Techniques need to be developed to couple ego-motion estimation and inertial navigation systems (INS) similar to the coupling of global positioning system/inertial navigation system GPS/INS systems. Coupling is often characterized as loose, tight, or ultra-tight depending on the nature of the GPS input to the navigation filter. Theoretically and practically for GPS/INS, the best performance is achieved under ultra-tight coupling were nearly raw GPS measurements are blended with similarly raw IMU measurements in the navigation filter to create a single system estimate of position and velocity. Optic flow processing has similar levels of output to GPS and should benefit from a similar development of tight or ultra-tight coupling. Under various types of coupling, performance models need to be developed to predict system level performance. It is assumed that truthed synthetic imagery representing a calibrated camera with known motion parameters will be used in phase I. Data sources will expand to real imagery in phase II and later with varying levels of calibration and motion truth to test algorithm rebustness. The development of optical IMU aiding would constitute an important advance in military applicability.

PHASE I: Identify methods to extend optical flow algorithms to characterize ego-motion. Develop methods for coupling INS with optic flow based ego-motion estimation. Some measures of performance include effective IMU drift, and navigation solution accuracy with and without optical aiding.

PHASE II: Build upon the initial phase I algorithms to improve robustness to variations in camera calibration and errors in camera motion measurement. Source data will expand to include real imagery with various levels of calibration and motion truth. Code should be matured to allow for closed loop simulation utilizing synthetic data and captive flight data.

DUAL USE COMMERCIALIZATION: Military application: In military use, this technology could be used to provide a low cost capability for precision navigation for guided submunitions or micro-air vehicles. Commercial application: Inexpensive precision navigation is also of interest for civilian aviation. This technology could also improve the accuracy of aerial surveying or reduce the cost of precision survey equipment.

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KEYWORDS: ego-motion, optic flow, inertial navigation, inertial measurement, video aided navigation

AF06-T033 TITLE: Stability Models for Augmentor Design Tools and Technology Assessment

TECHNOLOGY AREAS: Air Platform, Space Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: To develop stability models for computational fluid dynamics (CFD) design codes that can be used to design advanced, compact, stable, efficient augmentors.

DESCRIPTION: Augmentor designs are outside the current design space and future designs will require improved understanding of the physics of the augmentor flowfields to meet challenging design requirements for future augmentor systems. This deviation from conventional design methodology was driven by the need to achieve compact, lightweight, high performance augmentors that have operating conditions well outside state-of-the-art designs. Examples of this include the 50% increase in approach velocity and the use of combined spraybars/flameholders that have unfavorable aerodynamic characteristics for maintaining a stable flame. These changes in augmentor operating conditions and geometry affect dynamic and static stability of the system. Understanding the physics of these stability processes, robust, validated models to predict instabilities, and novel flame-holding designs to mitigate instabilities while maintaining high combustion efficiencies are needed to meet future augmentor design requirements.

In gas turbine augmentors, fuel flow is a direct function of altitude and Mach number. As the aircraft travels at lower altitudes and higher mach numbers, the oxygen concentration in the augmentor rises. This increase in oxygen concentration necessitates an increase in fuel flow to maintain stoichiometry. The penetration of the fuel spray is directly linked to the fuel flow. In the augmentor, the momentum of the fuel flow increases much faster than the momentum of the vitiated cross flow as the altitude decreases and the Mach number increases. Increase in jet penetration would dictate a change in the local stoichiometry of the augmentor such that static stability issues may become apparent. Oscillations in heat release, resulting from marginal static stability, may be a key factor in augmentor screech at these conditions.

To better understand this phenomena, an investigation of the static stability of the augmentor, at conditions where there is robust penetration, is required. Building blocks to static stability in the augmentor are vitiation level and vortex shedding. Current design approaches are based upon studies (e.g., the King (1957a, 1957b) and Dezubay (1958)) performed with preheated, but non-vitiated air. Yet, existing evidence shows that the combustion characteristics of vitiated and non-vitiated mixtures, even with the same oxygen content, are very different. Studying the effect of vitiation will elucidate the effect of the degree of vitiation on static stability. Subsequently, a linkage between the effect of vitiation on the static stability and its roll in the effect on dynamic stability can be learned.
Also important to static stability is vortex shedding. An investigation of vortex dynamics in bluff body stabilized flames, and the effect of these dynamics upon static and dynamic stability of the augmentor flame is required. Karman vortex sheet behind bluff bodies has been extensively studied in non-reacting flows (Panton, 1984). In combusting flows, Karman vortex shedding is also created behind the bluff body. The heat release at the flame also

causes a step increase in density across the flame. The cross product of this dilation of the gas, with the pressure gradients in the flow, result in the generation of vorticity otherwise not related to viscous effects, (Soteriou, and Ghoniem, 1998, and Ben-Yakar and Hanson, 1999, Soterio and Mehta, 2003). This baroclinic type vortex generation also dominates in reacting flows. A study of these effects is required to better understand the effect of vortex shedding on the static and subsequent dynamic stability in the augmentor.

PHASE I:
•Determine feasibility of developing stability models through the relationship between vitiation level and vortex shedding.
•Determine methodology for incorporation of models into existing CFD combustor and augmentor design codes.
•Identify novel augmentor flame-holding concepts.

PHASE II:
•Develop models that depict relationship between vitiation level, vorticity, static and dynamic stability.
•Incorporate stability models in CFD design codes and identify at least one novel augmentor concept that can improve stability and efficiency compared to a baseline design. Deliver model to AF research facility. Experimentally validate stability model through novel flame-holding concepts.

DUAL USE COMMERCIALIZATION: Military application: Models generated in the Phase II effort can be validated for sector rig and engine conditions and transitioned to Military Gas Turbine OEMs for incorporation into existing augmentor design system. Commercial application: Models generated in the Phase II effort can be further validated for sector rig and engine conditions and transitioned to Gas Turbine OEMs for incorporation into existing combustor design system. Improved augmentor design also will contribute to future civilian aircraft propulsion designs. NASA has been studying a supersonic business jet concept that utilizes augmented gas turbine propulsion technology. This program and commercial follow-on ventures will benefit from improved design capability.

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KEYWORDS: augmentor, combustion, static stability, dynamic stability, stability modeling, computational fluid dynamics, combustion systems

AF06-T034 TITLE: Novel Large, Flexible Light Emitting Arrays

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Development of high brightness, efficient light emitting arrays with high color purity, potential for long lifetime, and a "color" range from IR to UV using a unified device architecture.

DESCRIPTION: Recent research in thin film electroluminescent(EL) devices has demonstrated the possibility of producing large, flexible, bright, efficient, and inexpensive light emitting arrays for displays and for applications requiring broad area sources in a particular spectral region. Anticipated applications are, for example, large inexpensive displays, area lighting, optical interconnect, and printing. Promising array technologies include organic light emitting diodes (OLEDs), OLEDs incorporating nano-particles, and thin film EL arrays. These current technologies generally lack one or more of the characteristics which would make them more broadly applicable to challenging applications of interest, such as spatial light modulators. New inorganic approaches should be explored to demonstrate very desirable characteristics of long lifetime, high brightness, high efficiency, spectral purity, and/or the ability to create and modulate wavelengths from the infra-red to the UV, all using a unified architecture. Of particular interest are technologies which use inorganic lumophores which are, in general, more resistant to photo-induced degradation, which can emit purer colors through band gap and/or quantum confinement effects, and which can emit over a broader spectral range than current organic counterparts.

This topic is intended to advance one or more of these promising technologies toward meaningful commercial, industrial, and military practice by defining the technical and commercial requirements of particular applications and demonstrating the feasibility of meeting those requirements. This would advance several key technology areas of interest to the Air Force including the creation of bright narrowband non-coherent sources for laser pumping, development of optically active semiconductor materials, and the creation of narrowband hyperspectral light emitting arrays for high density optical memories and interconnects.

PHASE I: Define parameters for a specific application of a narrowband hyperspectral area light emitting array, and demonstrate the feasibility of chosen technology to meet that application.

PHASE II: Develop prototype large light emitting arrays which can meet the applications chosen, including the ability to manufacture at costs which will be acceptable to the market for those applications.

DUAL USE COMMERCIALIZATION: Military application: There are broad military needs for light sources with varying combinations of size, portability, efficiency, brightness, cost, etc. Displays are one obvious application, but more generally, other photonic systems can benefit greatly from an electrically controlled 2-D light source with broad spectral range (IR to UV) and narrow emission linewidths. These applications include maskless photolithography, memory, and communication systems. Commercial application: The arrays described above have potential for large volume civilian applications broadly in displays and in light sources for information technology, electronic, and medical markets which use photonic systems.

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KEYWORDS: OLED, microdischarge, display, array

AF06-T035 TITLE: Hearing Protection for High-Noise Environments

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop new, science-based approach to safeguard hearing in high-level noise exposure.

DESCRIPTION: Despite recent technical advances, hearing impairment remains the primary disability among military personnel. Power requirements and launching constraints currently require air crews to work in close proximity to aircraft engines where the sound pressure levels may exceed 150dB. Impulse noise, e.g. from large caliber weapons, can register peak pressures even higher.1 Effective hearing protection in such circumstances must provide superior attenuation at the ear without blocking auditory spatial awareness or compromising audio communication.2 Effectiveness may also be determined by comfort and usability factors.

In Defense Technology Objective DT0-HS-33, the Department of Defense has challenged the scientific and engineering community to provide at least 50dB attenuation for airborne sound at the eardrum. Much progress has been made toward this goal.2,3,4 However, non-airborne sound, e.g., "bone-conducted sound," remains a difficult problem, and is the principal focus of this STTR Topic.5,6 The problem is difficult because of a lack of fundamental knowledge regarding the transmission of acoustic energy through non-airborne pathways to the cochlea. One goal of this Topic is to measure and characterize the transfer functions for transmission to the cochlea via the skull, oral/nasal cavities, neck, jaw, torso, etc. Quantitative theoretical approaches may be needed, combined with bioacoustic and psychoacoustic assessments. For example, it is not known if bone-conducted loudness growth is nonlinear (compressed) at high levels, compared with air-conducted loudness. Research is also needed to characterize masking and threshold elevation phenomena, as well as effects on binaural hearing. Another goal is to develop and test new technical approaches to control exposure levels for non-airborne sound, in combination with airborne control, in accord with the effectiveness criteria mentioned above. This effort should not, however, attempt to circumvent the development of a secure base of bioacoustic and psychoacoustic knowledge needed to support the technical advance.

PHASE I: Perform bioacoustic and/or psychoacoustic measurements to determine non-airborne acoustic transmission to the cochlea. Develop a quantitative assessment of the effects on human hearing of non-airborne vs. airborne pathways, over a dynamic range relevant to military continuous noise above 130 dB SPL.

PHASE II: Refine the Phase I assessments and tools; use them to develop and test novel approaches applicable to military operational environments (e.g., as described by Bjorn, et al. or McKinley, et al. in ref. 5). This innovation should aim at mitigating the deleterious effects of non-airborne acoustic energy transmission to the cochlea, to optimize noise attenuation, spatial awareness, and voice communication.

PHASE III DUAL USE APPLICATIONS: This development of new technologies will be useful in commercial aviation, and in other high-noise environments such as mining, machining, construction, or metal fabrication. The measurement techniques and data will be useful in evaluating the performance of commercial systems for noise suppression, contact transducers for speech communication, hazard warning, and other acoustic devices.

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KEYWORDS: Noise, hearing protection, bone-conducted sound, acoustics

AF06-T037 TITLE: <u>Exploiting Microstructural Evolution for Material and Damage State Sensing</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Proposals are sought in the area of sensor development based on microstructural evolution concepts occurring in the sensor and/or coating.

DESCRIPTION: Integrated Structural Health Management (ISHM) is one of the key components of the Air Force's focused long term technical challenges and sensor technology for material and damage state sensing is a significant part of the overall ISHM strategy. While quite a few sensors suites are currently available for monitoring, for example, cracks and corrosion in aircraft many of these sensors are not suitable to operate in severe environments. High temperature sensor technology development is proceeding rapidly to meet the needs for severe environments but the capability of sensors to withstand severe /harsh environments is not well understood. Depending on the microstructure of the sensor, a certain operational temperature may initiate the degradation integrity of the original microstructure state through evolution of a new microstructure state/s. This evolving microstructural state can either be viewed as a degradation (of the original microstructural state and the sensor) and thus a limitation of the sensor capability or the phenomenon if well understood can be exploited as a means for sensing material and damage-state awareness. The purpose of the topic is to seek research proposals to interrogate materials components operating in a high temperature environment/ rotating components/ thermal protection structures etc. through microstructural evolution in sensor bulk materials and or sensor-coatings.

PHASE I: Development of technology, materials and processes for evolution and evaluation of microstructural features for use in sensors. Phase I will provide research into mechanisms, potential materials, and microstructural evolution processes.

PHASE II: Phase II will provide materials and processes for developing sensors that rely on microstructural evolution and features in high temperature material applications.

DUAL USE COMMERCIALIZATION: Military application: Applicable to all military high temperature propulsion and structural applications. Commercial application: Applicable to all commercial high temperature propulsion and structural applications.

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KEYWORDS: microstructural evolution, sensor development for high temperature applications

AF06-T038 TITLE: <u>Application of Non-Local Effects to Lasers and Plasma Chemistry in Flowing-Gas and Pulsed Electric Discharges.</u>

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Utilize the non-local nature of plasma electrons to improve the performance of various plasma devices under pulsed and flowing-gas applications.

DESCRIPTION: Flowing-gas and pulsed electric discharges exist in a variety of technical devices. Both the active phase of the discharge and the afterglow (downstream of the discharge or following extinction of the exciting pulse) can play important roles in a variety of plasma applications. In some cases, such as the electric discharge oxygen-iodine laser (ElectriCOIL), the afterglow is important due to the requirement of low electron temperature being vital for increased laser efficiency1. In plasma chemistry applications, a pulsed discharge allows an increase in instantaneous power delivery and some control the of near-wall plasma sheath, which may control many of the processes ongoing in the plasma2. It has been shown for cases where the pressure-path length product is less than 10 cm•Torr, that the non-local nature of the electron energy distribution is important and must be taken into account for plasma modeling in these systems3,4. The non-local nature of the electrons in these plasmas also allows the application of new methods for control of plasma parameters. One key area of interest centers around fast electrons created in the volume by plasma-chemical processes. Since one of these plasma-chemical processes is associative detachment in O-, this area will be of interest to electrically excited oxygen discharges, which include the ElectriCOIL, but may even include micro-discharges, operating in air, for possible chem-bio applications. This work would demonstrate the importance of fast electrons under the conditions present in the ElectriCOIL (first phase) and develop methods of regulation of the plasma properties (second phase) taking into account fast electrons (say, application of potentials to a part of the discharge walls and regulation of fast electron density).

PHASE I: Perform analysis (modeling) of a discharge system using a non-local approach. As a result of the non-local nature of the system (including the behavior of negative ions), suggested methods for controlling and tailoring the plasma parameters should be demonstrated in the model.

PHASE II: Experimentally demonstrate the effects of fast, non-local electrons on such discharge parameters as the near-wall sheath potential and the electron energy distribution function and compare with the models developed under Phase 1. Methods for control of the plasma parameters should be demonstrated.

DUAL USE COMMERCIALIZATION: Military application: There are a number of systems which could benefit from this type of analysis. These include discharges operating in air for chem-bio applications, and complex systems such as the ElectriCOIL. Commercial application: Control of sheath fields for nanotechnology applications such as carbon nanotube growth.

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KEYWORDS: non-local approach; electric discharge; electron detachment; sheath fields